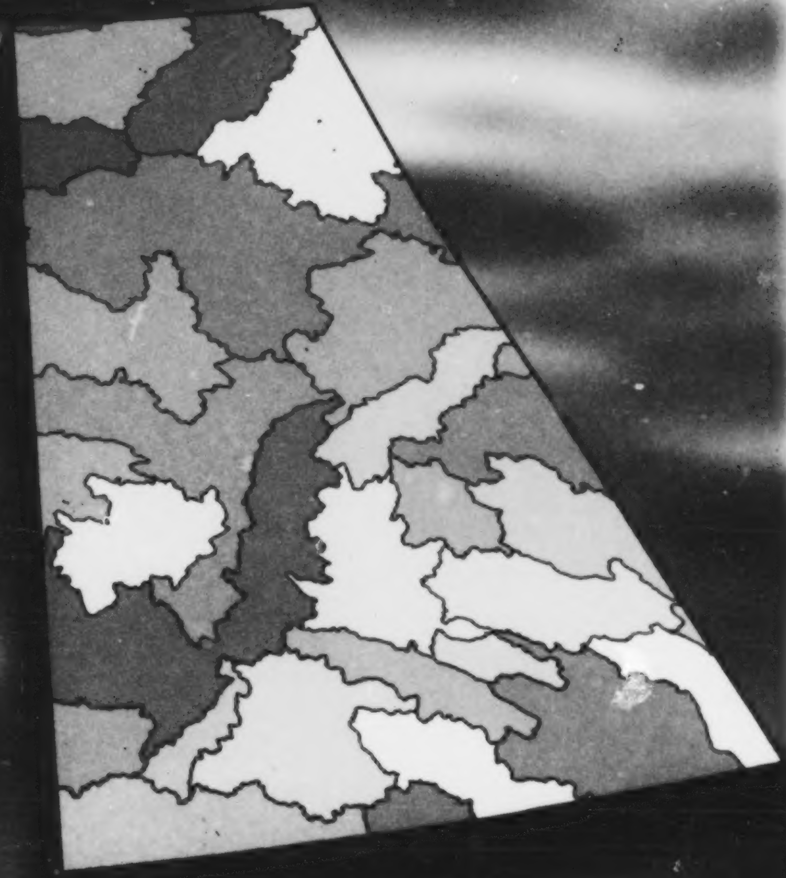
Saskatchewan
Watershed
Authority

Saskatchewan Watershed Authority

State of the Watershed Reporting Framework

January 2006



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Saskatchewan Watershed Authority

STATE OF THE WATERSHED REPORTING FRAMEWORK

Monitoring and Assessment Branch
Stewardship Division
January 2006

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Minister's Message

From the grasslands in the southwest to the Taiga Shield lakes of the north, we in Saskatchewan are blessed with richly diverse ecosystems. Over the past few decades, we have come to understand more about the nature of these ecosystems, and how we rely on them to support our economy and our overall quality of life. We have also increased our understanding of the responsibility we bear to assess, protect and improve our province's environmental health, in balance with our social and economic priorities, for the good of present and future generations.

We face a number of challenges regarding our water's quality and availability. It is up to Saskatchewan people to determine how we will meet these challenges.

The Saskatchewan government has taken a leadership role in assessing, protecting and managing our source waters by addressing them at the watershed level. The *State of the Watershed Reporting Framework* represents a critical step in understanding our relationship with Saskatchewan's watersheds, as well as our role as stewards of our environment.

For the first time in Saskatchewan, this framework will integrate the information collected by numerous provincial and federal agencies and present it in an easily understandable, technically sound report-card format. This reporting method will provide the people of Saskatchewan with a far more complete picture of Saskatchewan's watersheds than has ever been available before, as well as a more detailed understanding of how our actions impact watershed health and function.

The information in these reports will assist stakeholder groups and individual citizens to improve decision-making regarding our domestic, agricultural, industrial, and recreational water uses. This framework will also allow us to chart our management goals for each watershed and for the province as a whole, as well as to measure our progress in meeting these stated goals.

The *State of the Watershed Reporting Framework* is an important component in support of Saskatchewan's Green Strategy. This strategy provides a vital framework to support our commitment to expand our economy while ensuring the long-term sustainability of our environment. It calls on government, business and the community to work together to ensure a green and prosperous future for our province. Clearly, the proper assessment, management and protection of our precious water resources will be key to achieving these goals.

I am very proud to release the *State of the Watershed Reporting Framework* as it is a significant step towards deepening our understanding of these issues, and ensuring the future health of our watersheds.

The Honourable David Forbes

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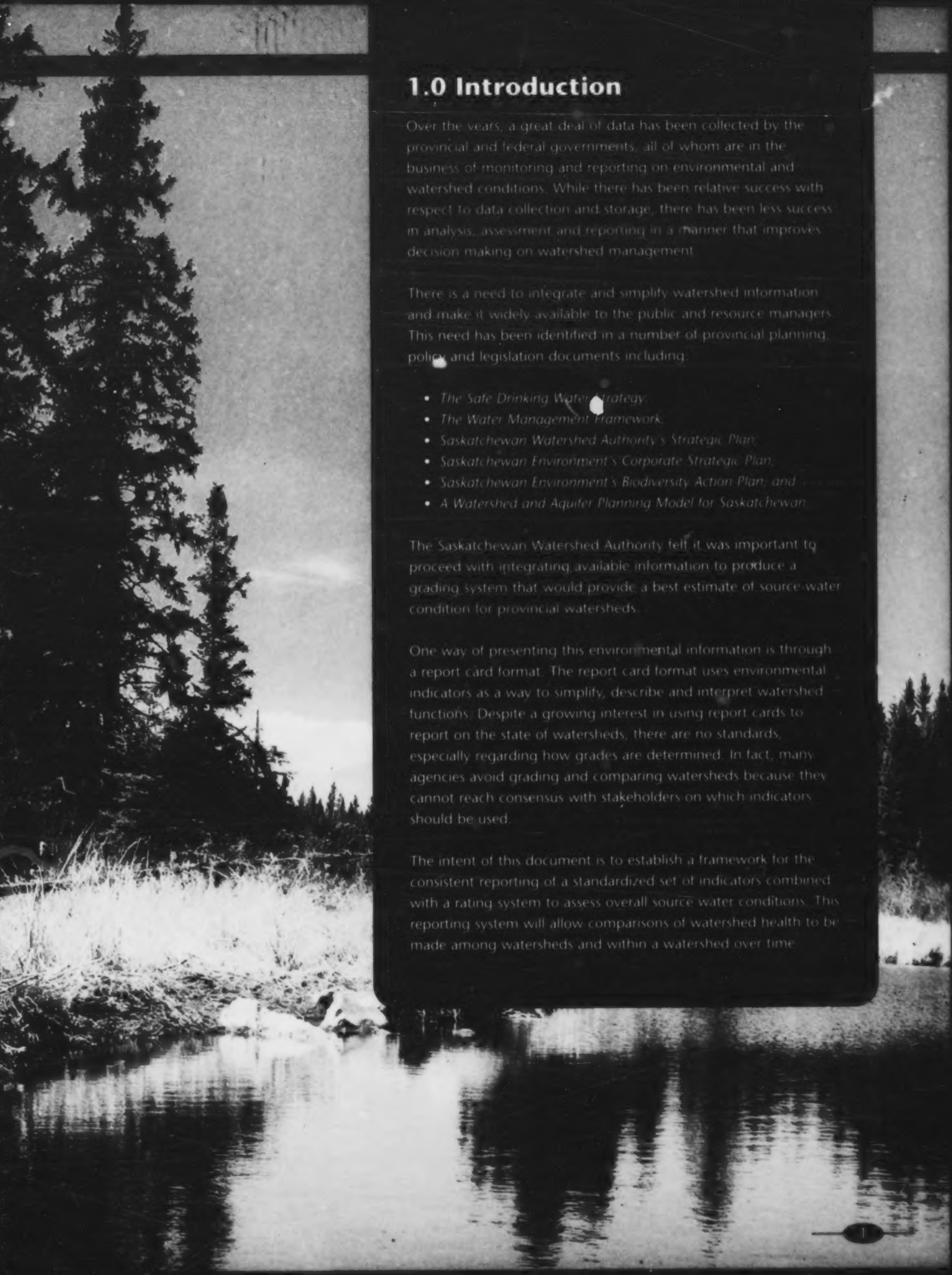


1.0 Introduction

Over the years, a great deal of data has been collected by the provincial and federal governments, all of whom are in the business of monitoring and reporting on environmental and watershed conditions. While there has been relative success with respect to data collection and storage, there has been less success in analysis, assessment and reporting in a manner that improves decision making on watershed management.

There is a need to integrate and simplify watershed information and make it widely available to the public and resource managers. This need has been identified in a number of provincial planning, policy and legislation documents including:

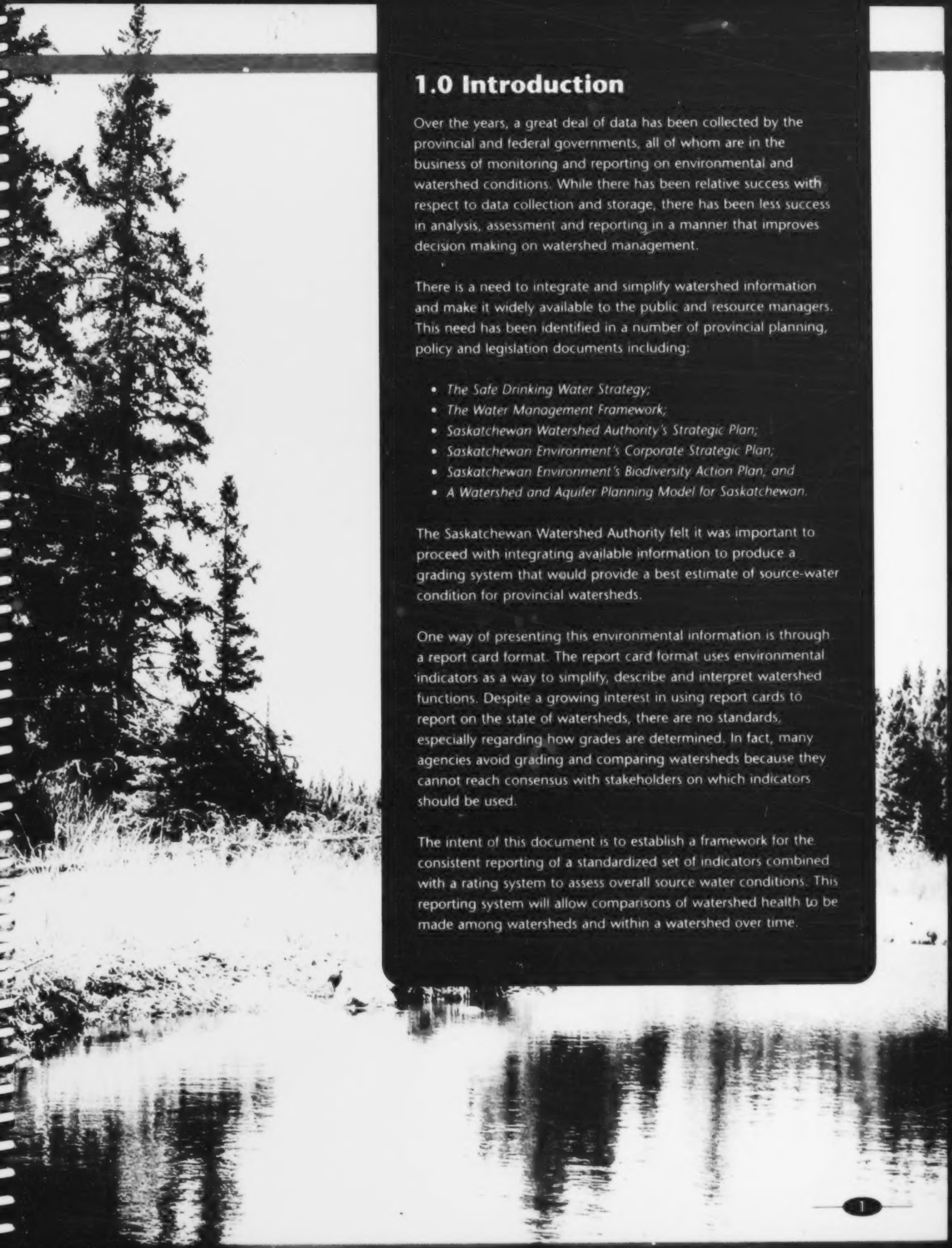
- *The Safe Drinking Water Strategy;*
- *The Water Management Framework;*
- *Saskatchewan Watershed Authority's Strategic Plan;*
- *Saskatchewan Environment's Corporate Strategic Plan;*
- *Saskatchewan Environment's Biodiversity Action Plan; and*
- *A Watershed and Aquifer Planning Model for Saskatchewan.*

The Saskatchewan Watershed Authority felt it was important to proceed with integrating available information to produce a grading system that would provide a best estimate of source water condition for provincial watersheds.

One way of presenting this environmental information is through a report card format. The report card format uses environmental indicators as a way to simplify, describe and interpret watershed functions. Despite a growing interest in using report cards to report on the state of watersheds, there are no standards, especially regarding how grades are determined. In fact, many agencies avoid grading and comparing watersheds because they cannot reach consensus with stakeholders on which indicators should be used.

The intent of this document is to establish a framework for the consistent reporting of a standardized set of indicators combined with a rating system to assess overall source water conditions. This reporting system will allow comparisons of watershed health to be made among watersheds and within a watershed over time.

Photos courtesy of (clockwise from top left): Saskatchewan Industry and Resources; Saskatchewan Agriculture and Food; Saskatchewan Watershed Authority; Nature Saskatchewan; Saskatchewan Watershed Authority; Nature Saskatchewan; and Saskatchewan Watershed Authority.



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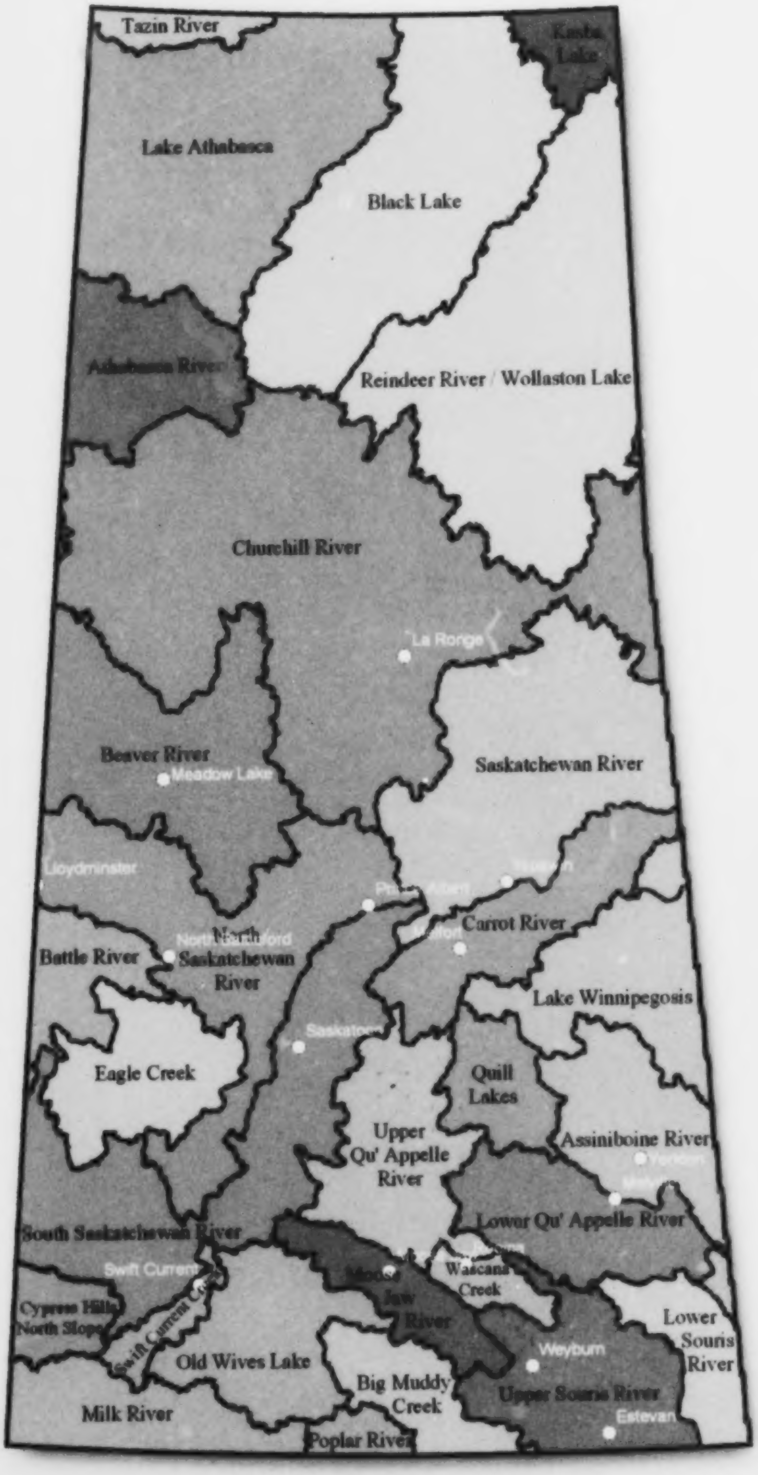

Tazin River
Kasba Lake
Lake Athabasca
Black Lake
Athabasca River
Reindeer River / Wollaston Lake
Churchill River
La Ronge
Beaver River
Meadow Lake
Saskatchewan River
Lloydminster
Prince Albert
Nipawin
Carrot River
Melfort
North Battleford
North Saskatchewan River
Battle River
Lake Winnipegosis
Saskatoon
Eagle Creek
Quill Lakes
Upper Qu' Appelle River
Assiniboine River
Yorkton
Melville
Lower Qu' Appelle River
South Saskatchewan River
Swift Current
Regina
Moose Jaw River
Wascana Creek
Cypress Hills North Slope
Swift Current Creek
Lower Souris River
Weyburn
Old Wives Lake
Big Muddy Creek
Upper Souris River
Estevan
Milk River
Poplar River

Figure 1. Saskatchewan Watershed Authority's twenty-nine watersheds.

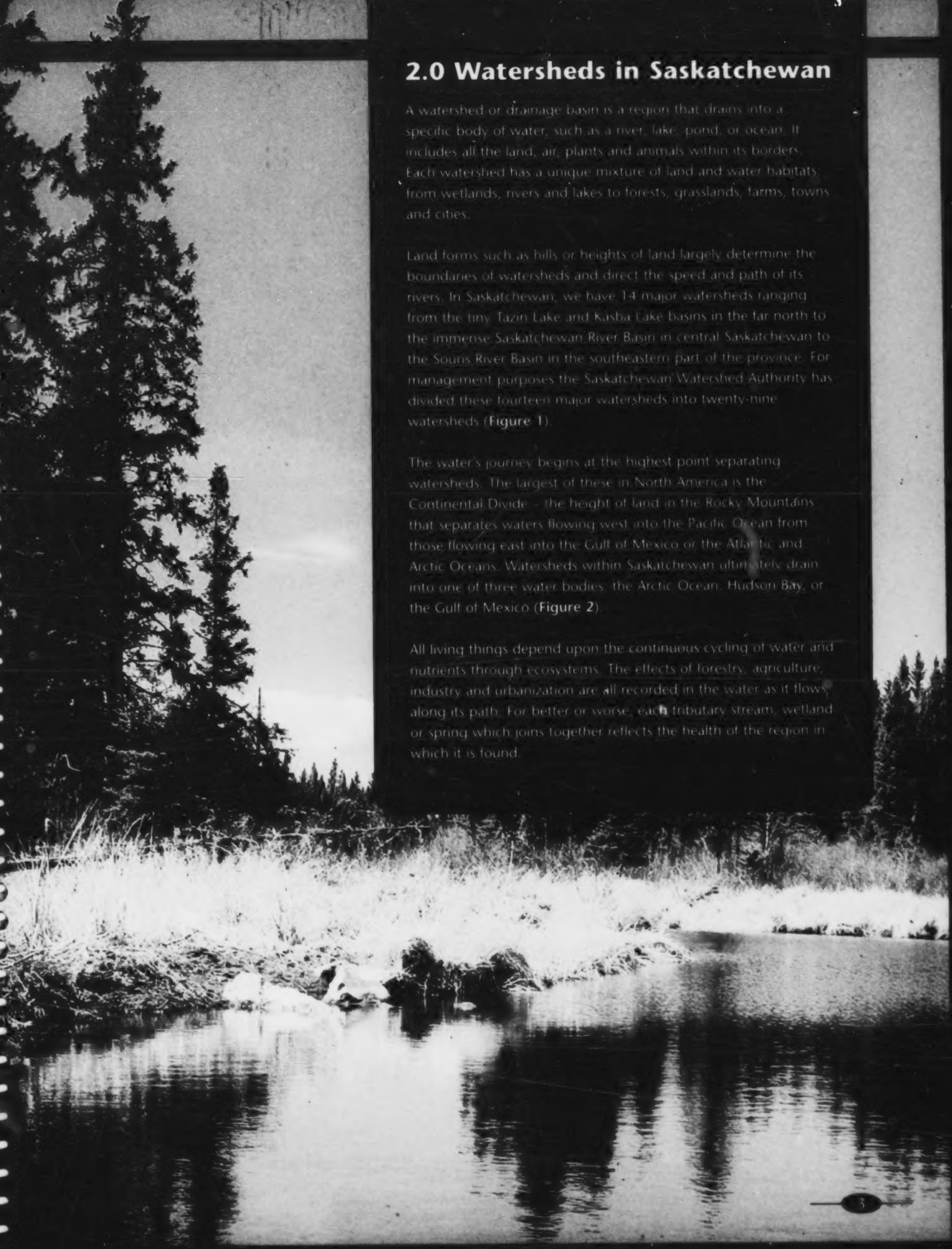
2.0 Watersheds in Saskatchewan

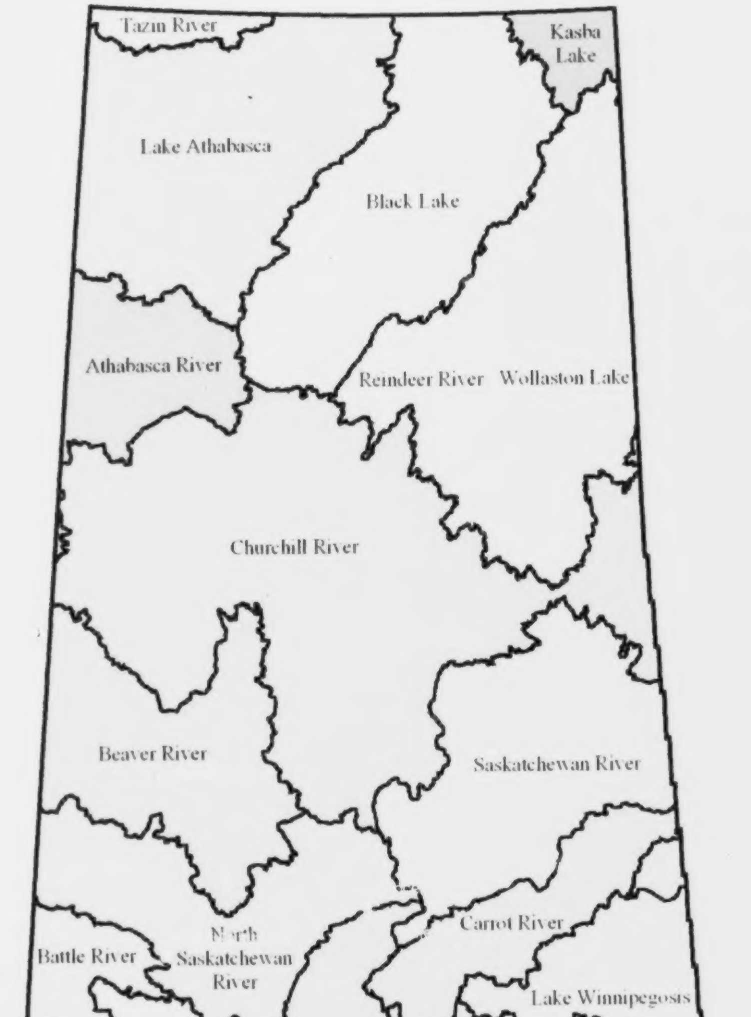
A watershed or drainage basin is a region that drains into a specific body of water, such as a river, lake, pond, or ocean. It includes all the land, air, plants and animals within its borders. Each watershed has a unique mixture of land and water habitats from wetlands, rivers and lakes to forests, grasslands, farms, towns and cities.

Land forms such as hills or heights of land largely determine the boundaries of watersheds and direct the speed and path of its rivers. In Saskatchewan, we have 14 major watersheds ranging from the tiny Tazin Lake and Kasba Lake basins in the far north to the immense Saskatchewan River Basin in central Saskatchewan to the Souris River Basin in the southeastern part of the province. For management purposes the Saskatchewan Watershed Authority has divided these fourteen major watersheds into twenty-nine watersheds (**Figure 1**).

The water's journey begins at the highest point separating watersheds. The largest of these in North America is the Continental Divide – the height of land in the Rocky Mountains that separates waters flowing west into the Pacific Ocean from those flowing east into the Gulf of Mexico or the Atlantic and Arctic Oceans. Watersheds within Saskatchewan ultimately drain into one of three water bodies: the Arctic Ocean, Hudson Bay, or the Gulf of Mexico (**Figure 2**).

All living things depend upon the continuous cycling of water and nutrients through ecosystems. The effects of forestry, agriculture, industry and urbanization are all recorded in the water as it flows along its path. For better or worse, each tributary stream, wetland or spring which joins together reflects the health of the region in which it is found.

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Wollaston Lake
Churchill River
Beaver River
Saskatchewan River
Carrot River
Battle River
North Saskatchewan River
Lake Winnipegosis
Eagle Creek
Quill Lakes
Upper Qu' Appelle River
Assiniboine River
Lower Qu' Appelle River
South Saskatchewan River
Moose Jaw River
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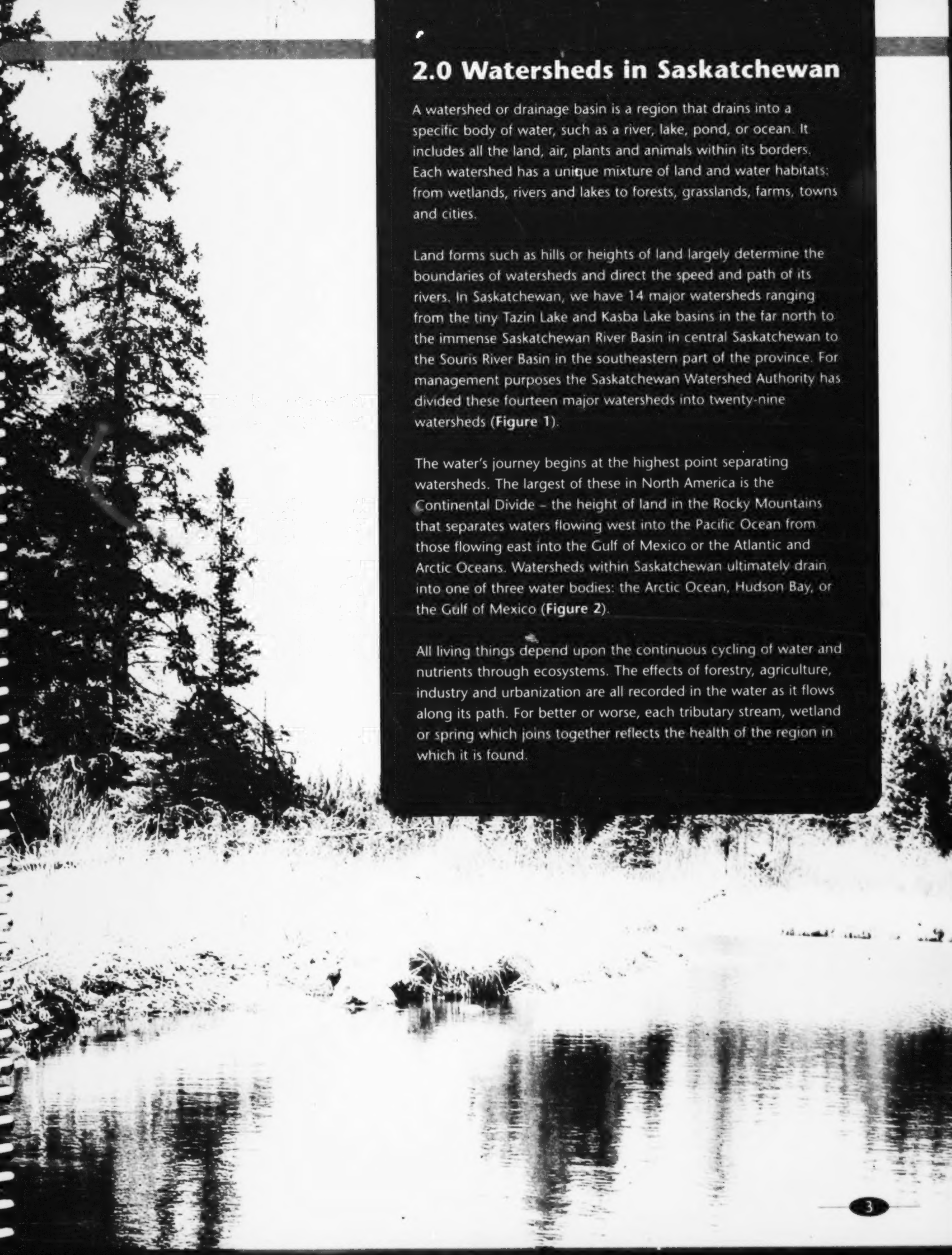

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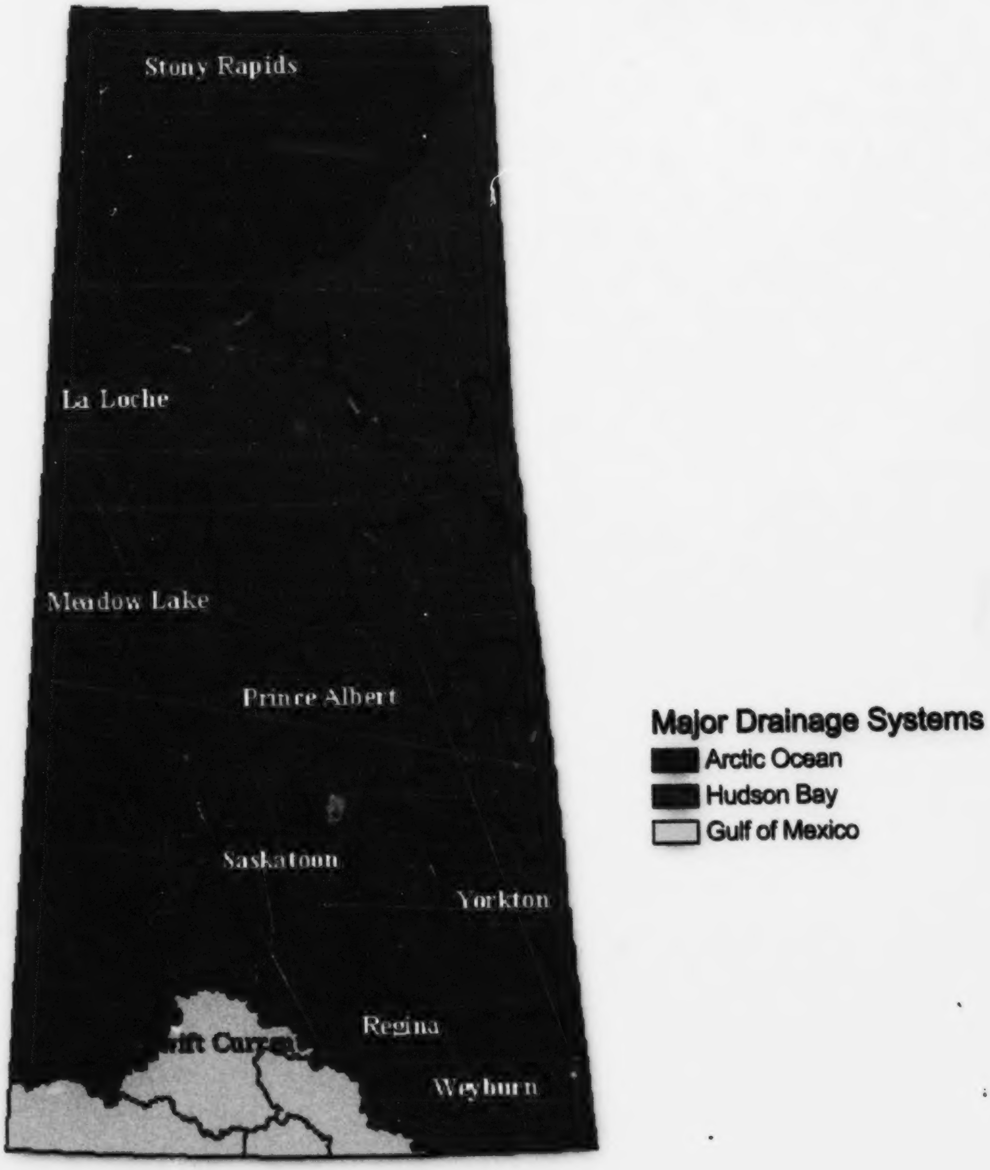
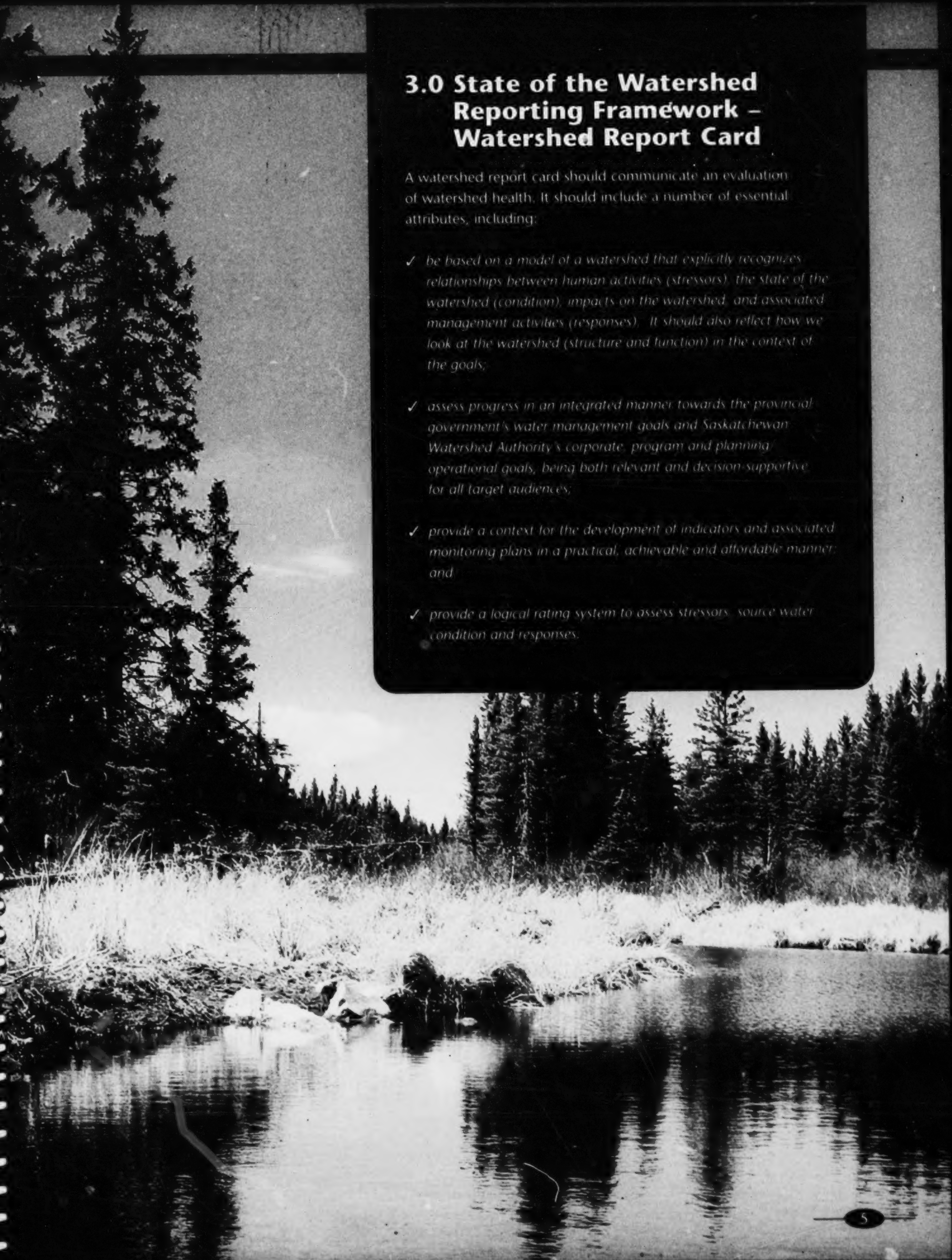

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
wift Curren
Weyburn
Major Drainage Systems
Arctic Ocean
Hudson Bay
Gulf of Mexico

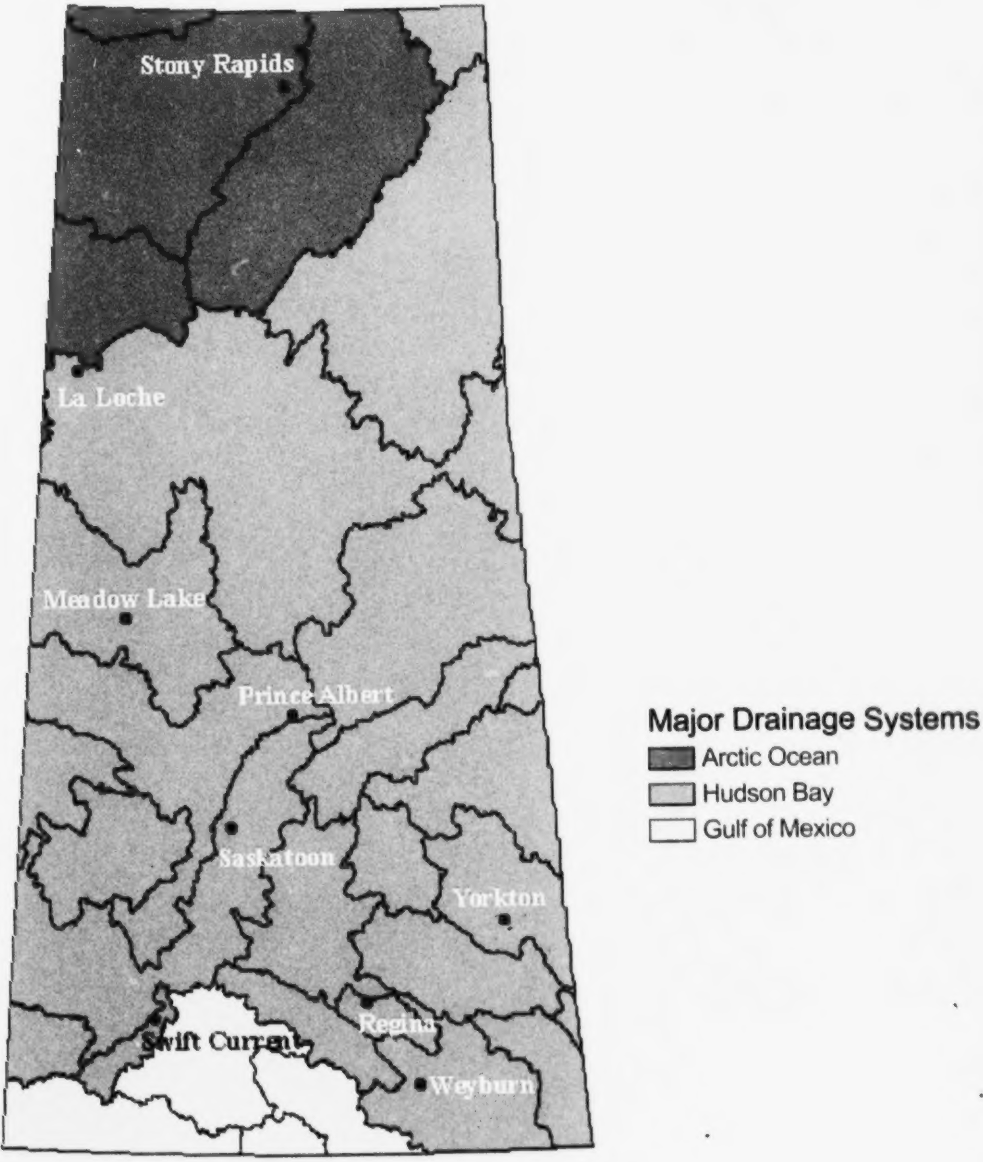
Figure 2. Saskatchewan's three major drainage systems.

3.0 State of the Watershed Reporting Framework – Watershed Report Card

A watershed report card should communicate an evaluation of watershed health. It should include a number of essential attributes, including:

- ✓ *be based on a model of a watershed that explicitly recognizes relationships between human activities (stressors), the state of the watershed (condition), impacts on the watershed, and associated management activities (responses). It should also reflect how we look at the watershed (structure and function) in the context of the goals;*
- ✓ *assess progress in an integrated manner towards the provincial government's water management goals and Saskatchewan Watershed Authority's corporate, program and planning/operational goals, being both relevant and decision-supportive for all target audiences;*
- ✓ *provide a context for the development of indicators and associated monitoring plans in a practical, achievable and affordable manner; and*
- ✓ *provide a logical rating system to assess stressors, source water condition and responses.*

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☐ Gulf of Mexico

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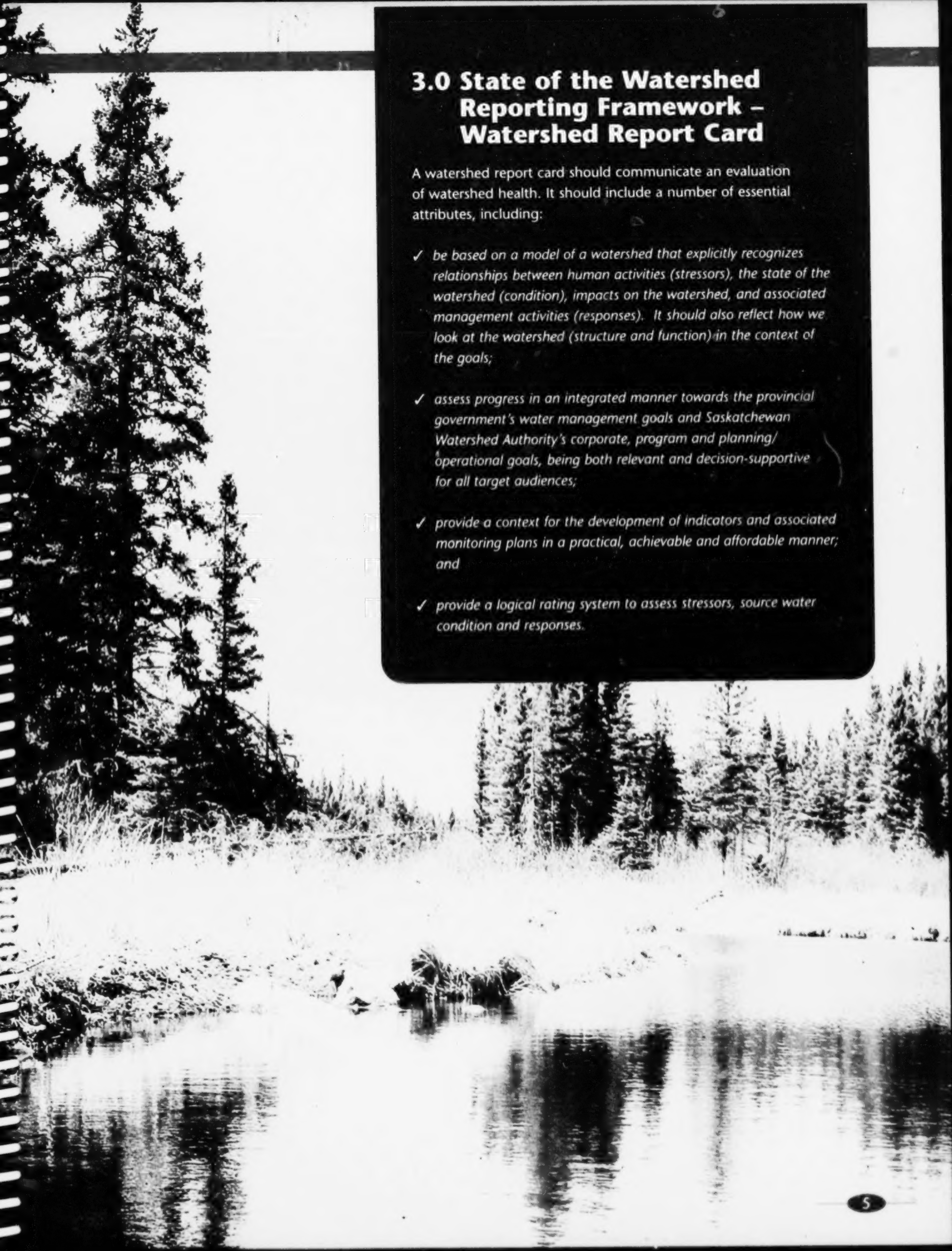

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A conceptual model of watershed functioning is necessary to effectively relate human activity with ecosystem health. The premise behind such a model is that a human activity can impose a *stress* that may impact the *condition* of the watershed, which requires a management *response* to counteract the stress. The proposed *Stress-Condition-Response* Model is presented in Figure 3.

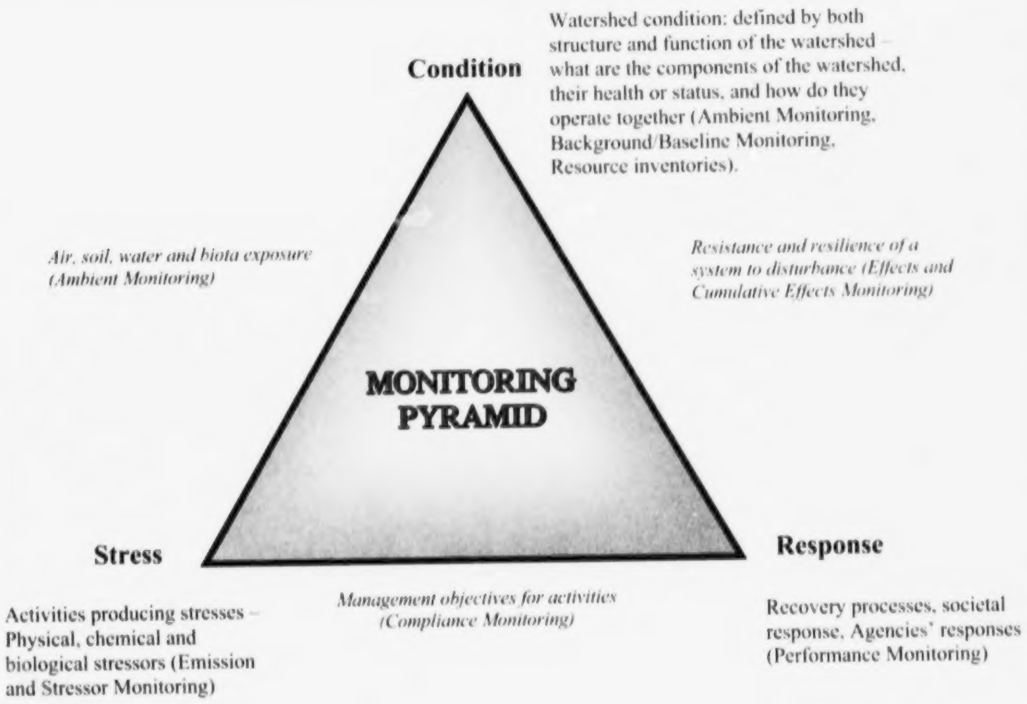
Condition
Watershed condition: defined by both structure and function of the watershed – what are the components of the watershed, their health or status, and how do they operate together (Ambient Monitoring, Background/Baseline Monitoring, Resource inventories).
Air, soil, water and biota exposure (Ambient Monitoring)
Resistance and resilience of a system to disturbance (Effects and Cumulative Effects Monitoring)
MONITORING PYRAMID
Stress
Response
Activities producing stresses – Physical, chemical and biological stressors (Emission and Stressor Monitoring)
Management objectives for activities (Compliance Monitoring)
Recovery processes, societal response, Agencies' responses (Performance Monitoring)

Figure 3. *Stress-Condition-Response* Model demonstrating the relationship between various watershed health components.

As an example of how the model works, cattle grazing in riparian areas (*stress*) can change the composition of streamside vegetation and reduce bank stability (*condition*). Installation of off-site watering facilities, fencing, or implementation of alternative management practices would be the *response*. In a monitoring sense, cattle grazing could be assessed by tracking the number of animals grazing within a riparian area over a designated time period, or more simply by noting whether an area is grazed or not. Similarly, riparian vegetation could be assessed and tracked through various measurements of composition and structure. The response could be assessed by noting improved water quality and bank stability and structure.

Table 1 provides an example of how the model can be used to assess habitat loss into *stress, condition,* and *response* components.

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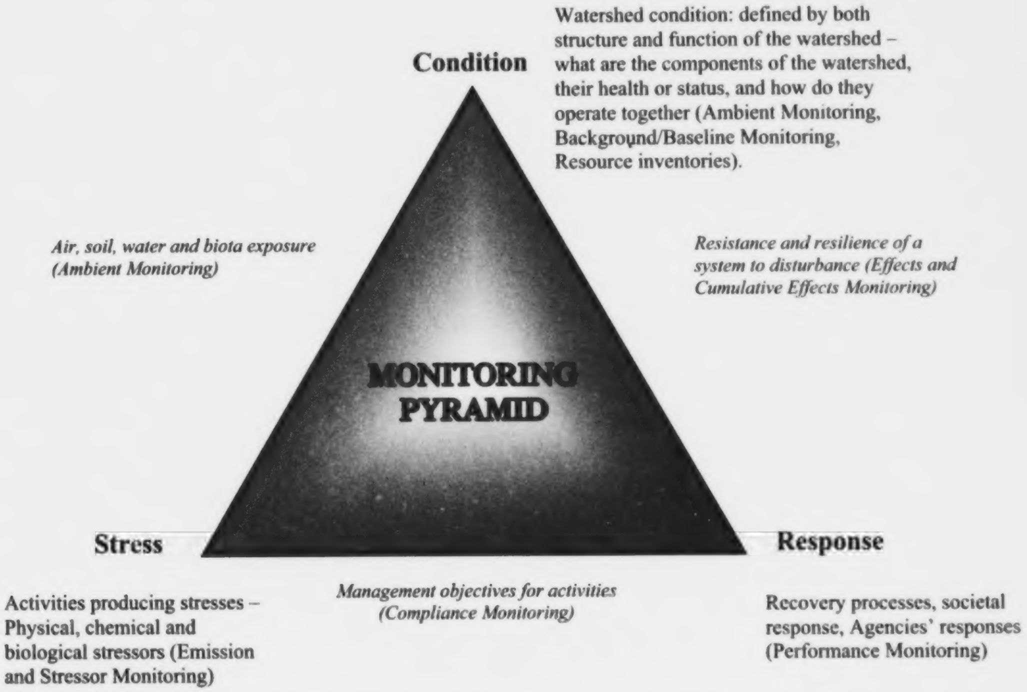

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Air, soil, water and biota exposure (Ambient Monitoring)

Resistance and resilience of a system to disturbance (Effects and Cumulative Effects Monitoring)

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Management objectives for activities (Compliance Monitoring)

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Table 1 provides an example of how the model can be used to assess habitat loss into *stress*, *condition*, and *response* components.

Table 1. Application of the *Stress-Condition-Response* Model.

Stress	*Condition*	*Response*
Agricultural practices	Drainage of wetlands - loss of wetland structure and function - decline in associated species abundance	Land-based incentives to maintain critical wetland areas, policy and legislative implementation
Urban expansion	Movement into adjacent habitats - loss of flora and fauna - alteration of trophic structure	Protection of sensitive or crucial areas, implementation of stewardship activities to minimize impacts
Forest harvesting	Removal or destruction of riparian areas - loss of flora and fauna - degraded buffering function, increases in sedimentation and nutrient loading	Protection of buffer strips and limitation of harvesting within riparian zones, monitoring of impacts and operational guideline restrictions

In addition to providing a template on which to base watershed monitoring, assessment and reporting, the *Stress-Condition-Response* Model:

- links stresses, due to specific activities, with watershed responses, forming the basis for watershed planning;
- links management activities and monitoring, to provide a more comprehensive approach to watershed management;
- relates all aspects of watershed monitoring (i.e. stresses lead to watershed condition, and responses aim to relieve stresses and improve condition);
- identifies data gaps and areas where future resources and effort should be focused, including increased understanding of critical thresholds at which ecosystems become impaired and their ability to function is lost; and
- provides a context for the development of indices/indicators to characterize risks, watershed conditions or management issues in a meaningful way for users.

A watershed report card should: ***assess progress in an integrated manner towards Saskatchewan Watershed Authority's corporate, program and planning/operational goals, being both relevant and decision-supportive for all target audiences.***

The impetus of a watershed reporting framework is to assess and measure progress from an overall government view, both from a corporate perspective and on the planning level for the major watersheds within the province.

Objective one of Saskatchewan's Water Management Framework, 1999, states "maintain, restore and protect the health of aquatic and riparian ecosystems and drinking water sources." This objective inherently implies the need to understand the status of watershed health to develop effective management and protection strategies. Key actions under this objective include:

- develop indicators and monitor the health of drinking water sources and aquatic ecosystems; and
- establish criteria for rating aquatic ecosystem integrity that can be used to improve decision making.

There are two objectives in Saskatchewan's Safe Drinking Water Strategy that directly tie in with State of the Watershed Reporting:

- risks (stressors) to source water quality are known; and
- citizens have meaningful access to information about the quality of their water.

The Saskatchewan Watershed Authority's Strategic Plan states, under Goal 2 (Healthy Watersheds), that the Authority will "*regularly evaluate the state of the watersheds.*" This evaluation needs to be tied to the other stated goals and objectives in the Strategic Plan. These goals and objectives provide the focus, direction and management priorities under which the Saskatchewan Watershed Authority will develop and implement watershed reporting. The relevant objectives of reporting are to ensure that:

- Watersheds are protected, natural purification and protection processes are maximized and the potential for contamination is minimized;
- A safe and sustainable water supply is maintained;
- Water management infrastructure is safe and effective; and
- There is sound knowledge of the quality, quantity and distribution of water supplies.

The *Stress-Condition-Response* Model will be used to describe the present status of the objectives listed above and will be used as a point of discussion on the response aspect of the model. The description will include:

- Water quality;
- Water quantity and flows – surface and groundwater;
- Vegetation – riparian and wetland areas;
- Aquatic life;
- Soils;
- Climate;
- Infrastructure – dams, control structures, treatment plants, and transportation corridors;
- Land cover and use;
- Population demographics; and
- Water use and allocation.

A watershed report card should: ***provide a context for the development of indicators and associated monitoring plans in a practical, achievable and affordable manner.***

Indicators are the tools of the State of the Watershed Reporting Framework. They characterize the issues in a meaningful way. Indicators are a reflection of the environmental and resource management questions, whether those questions relate to ecosystem health, department progress or specific regional concerns. They may be quantitative, descriptive, projective or predictive in nature. Indicators may include information from a combination of several variables. They allow for more simplified analysis of complex ecological functions.

The Saskatchewan Watershed Authority and Saskatchewan Environment have implemented, and in some cases developed, many indicators and indices. Examples include the Water Quality Index (developed by the Canadian Council of Ministers of the Environment 2001) and the Habitat Assessment Index (developed by the University of Montana and Saskatchewan Wetland Conservation Corporation) for the assessment of riparian habitats.

The goal of using these indicators and indices is to effectively summarize and communicate the status of complex ecological systems into a form that is appropriate for water management applications and

public understanding. The Saskatchewan Watershed Authority proposes to use a series of indicators in the context of the *Stress-Condition-Response* Model. The proposed indicators have a number of key features:

- They quantify information such that its importance is more apparent;
- They simplify information from complex ecosystems to improve communication with the public and with decision-makers;
- They are a cost-effective and representative alternative to monitoring infinite individual processes; and
- They can be implemented and updated in an appropriate time frame for the State of the Watershed Reporting.

A watershed report card should: ***provide a logical rating system to assess stressors, source water condition and responses.***

A review of the scientific literature was conducted to find logical and appropriate rating schemes for the stress, condition and response indicators. When insufficient data from appropriate scientific studies existed to rate stress or condition indicators, the Jenks' optimization method was used to find the natural breaks in the data. This method minimizes the squared variation of the means within the class, while maximizing the squared variation between the classes. The results of the Jenks' optimization method may change as more data are included. This rating scheme is intended to be used to compare all watersheds within Saskatchewan. A low stress rating simply means that the watershed scored lower relative to other watersheds based on the criteria being rated.

Based on the above assessment methods, the following rating schemes were used:

Stress indicators were classified into three classes - Low, Moderate and High stress potential.

- The stress indicator is shown as green on the Saskatchewan watershed map when the stress potential is Low; orange when the stress potential is Moderate; red when the stress potential is High; and white if there is a data gap.

The existence of a stress rating does not necessarily reflect the health of a watershed. For example, a stress indicator with a High stress rating does not implicitly mean that the health of the watershed is Impaired. Conversely, a stress indicator with a Low stress rating does not necessarily mean that the watershed is Healthy.

Condition indicators were classified into three classes - Healthy, Stressed and Impaired condition.

- The condition indicator is shown as green on the Saskatchewan watershed map when the condition of the watershed is Healthy; orange when the watershed is Stressed; red when the watershed is Impaired; and white if there is a data gap.

Response indicators were classified as Present or Absent.

- The response indicator is shown as green on the Saskatchewan watershed map when there is an appropriate response to the stress, red if there is no appropriate response.

Figure 4 is an example of how an indicator will look when mapped by Saskatchewan's watersheds. This example is a map of the estimated percent permanent cover (condition indicator) by watershed. The map shows that when the estimated permanent cover is greater than 46%, the watershed is Healthy, and the watershed is shaded green. When the estimated permanent cover is between 27% and 46%, the watershed is Stressed, and the watershed is shaded orange. When the estimated permanent cover is less than 26%, the watershed is Impaired, and the watershed is shaded red.

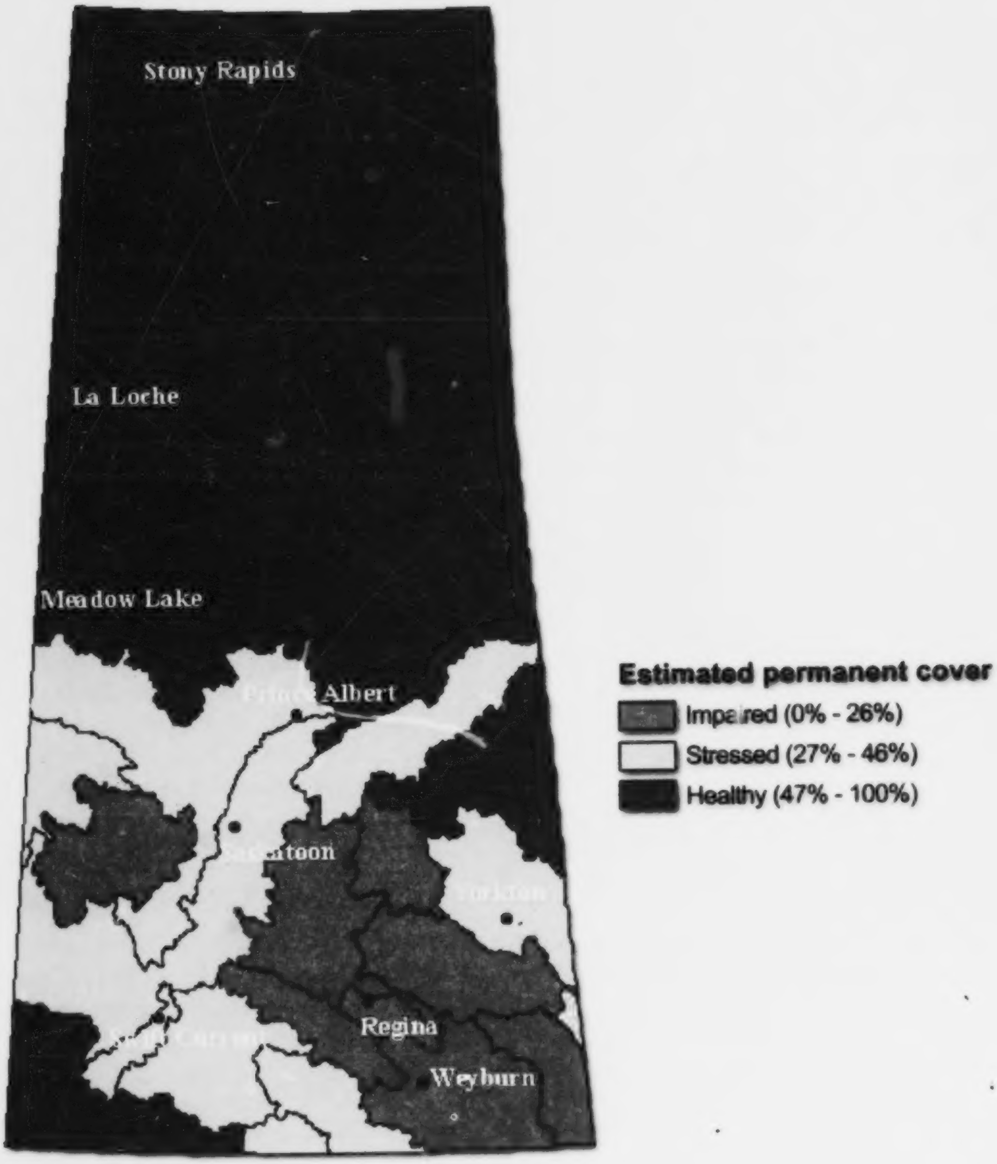
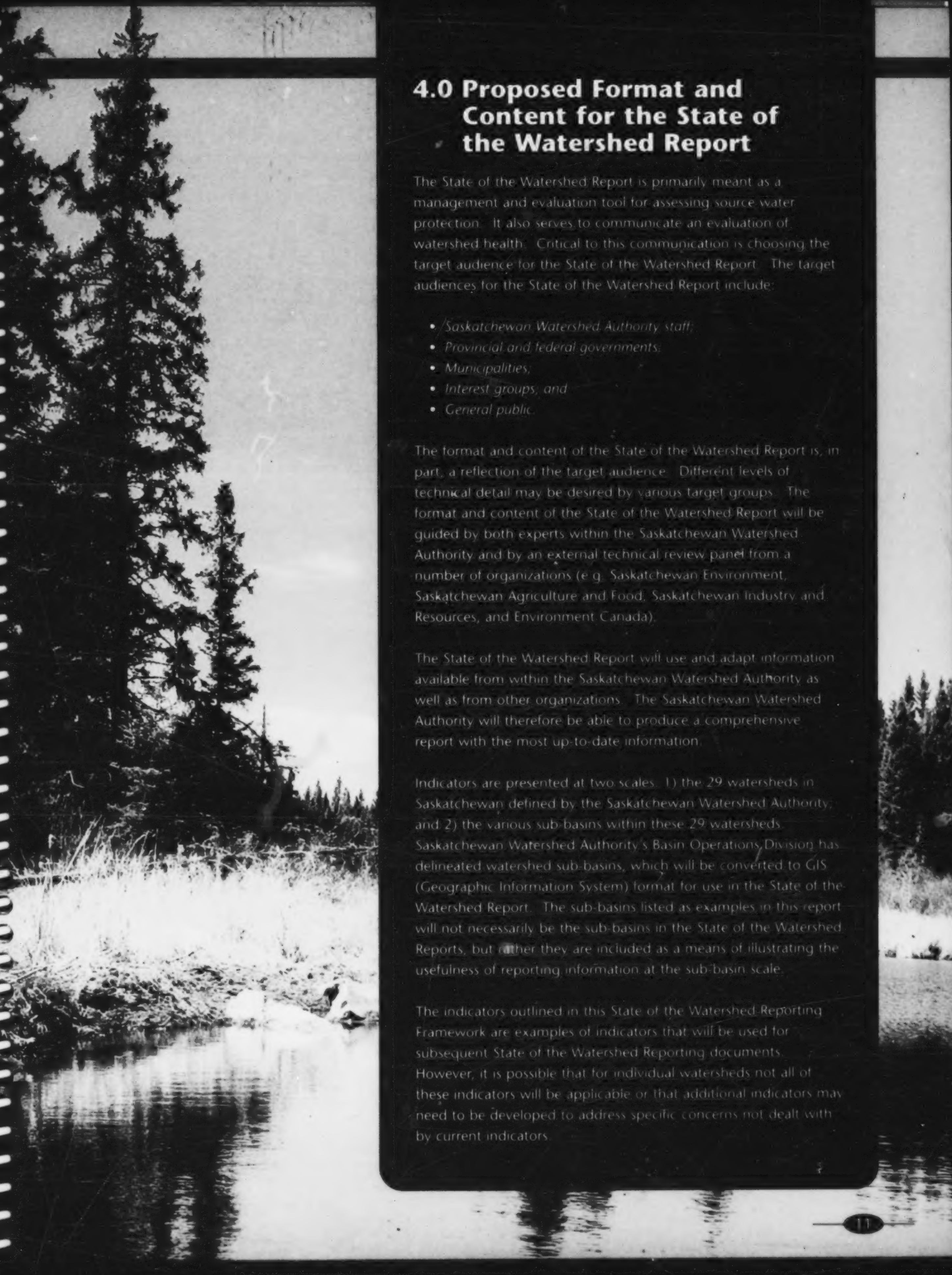

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Estimated permanent cover
Impaired (0% - 26%)
Stressed (27% - 46%)
Healthy (47% - 100%)

Figure 4. Estimate of permanent cover by watershed.



4.0 Proposed Format and Content for the State of the Watershed Report

The State of the Watershed Report is primarily meant as a management and evaluation tool for assessing source water protection. It also serves to communicate an evaluation of watershed health. Critical to this communication is choosing the target audience for the State of the Watershed Report. The target audiences for the State of the Watershed Report include:

- *Saskatchewan Watershed Authority staff;*
- *Provincial and federal governments;*
- *Municipalities;*
- *Interest groups; and*
- *General public.*

The format and content of the State of the Watershed Report is, in part, a reflection of the target audience. Different levels of technical detail may be desired by various target groups. The format and content of the State of the Watershed Report will be guided by both experts within the Saskatchewan Watershed Authority and by an external technical review panel from a number of organizations (e.g. Saskatchewan Environment, Saskatchewan Agriculture and Food, Saskatchewan Industry and Resources, and Environment Canada).

The State of the Watershed Report will use and adapt information available from within the Saskatchewan Watershed Authority as well as from other organizations. The Saskatchewan Watershed Authority will therefore be able to produce a comprehensive report with the most up-to-date information.

Indicators are presented at two scales: 1) the 29 watersheds in Saskatchewan defined by the Saskatchewan Watershed Authority; and 2) the various sub-basins within these 29 watersheds. Saskatchewan Watershed Authority's Basin Operations Division has delineated watershed sub-basins, which will be converted to GIS (Geographic Information System) format for use in the State of the Watershed Report. The sub-basins listed as examples in this report will not necessarily be the sub-basins in the State of the Watershed Reports, but rather they are included as a means of illustrating the usefulness of reporting information at the sub-basin scale.

The indicators outlined in this State of the Watershed Reporting Framework are examples of indicators that will be used for subsequent State of the Watershed Reporting documents. However, it is possible that for individual watersheds not all of these indicators will be applicable or that additional indicators may need to be developed to address specific concerns not dealt with by current indicators.

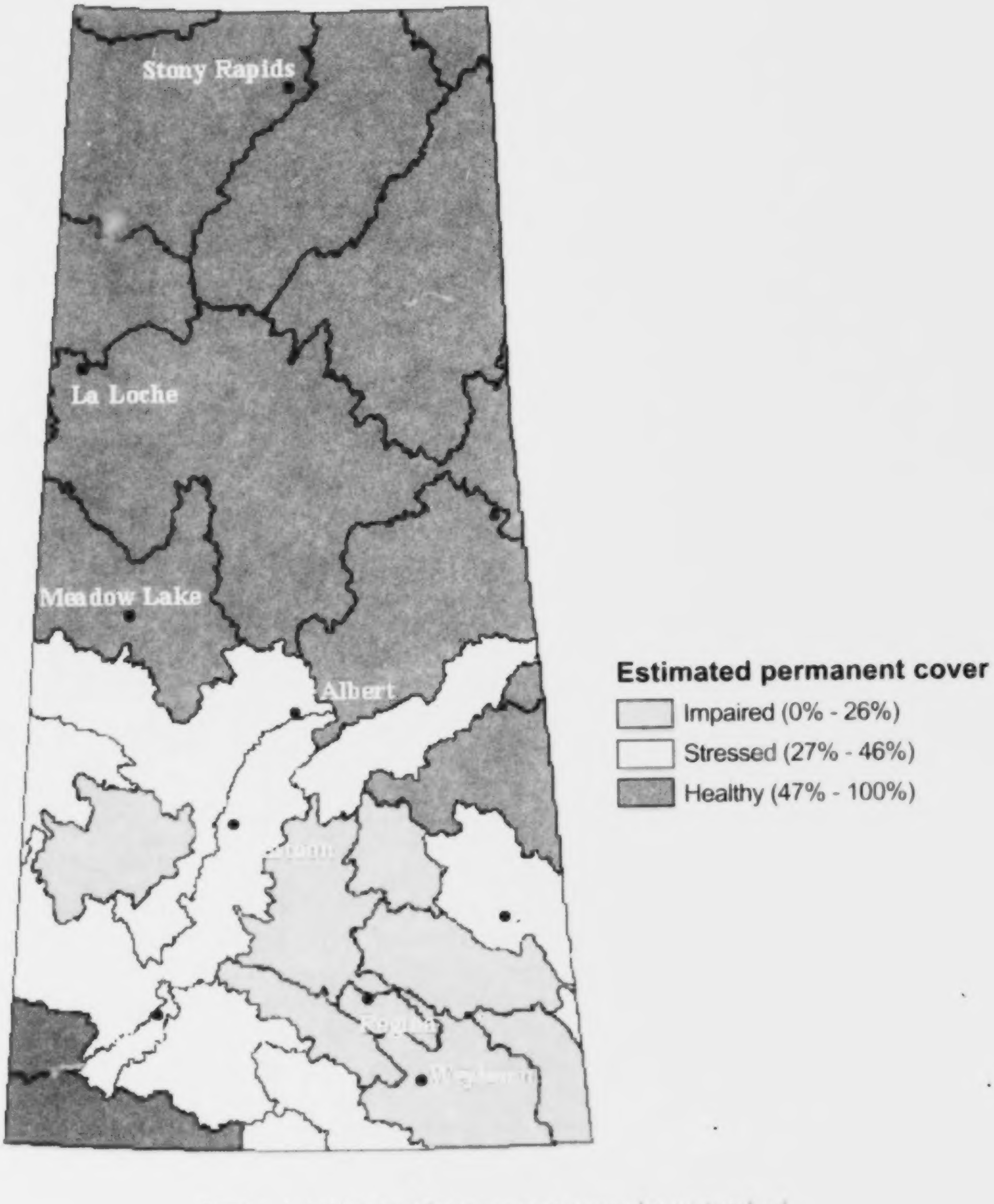

Stony Rapids
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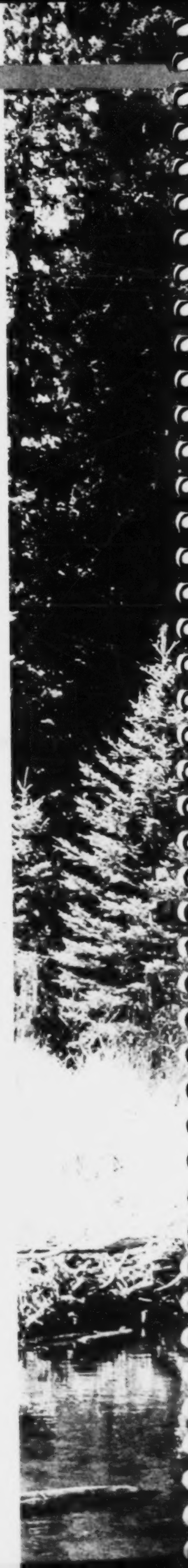
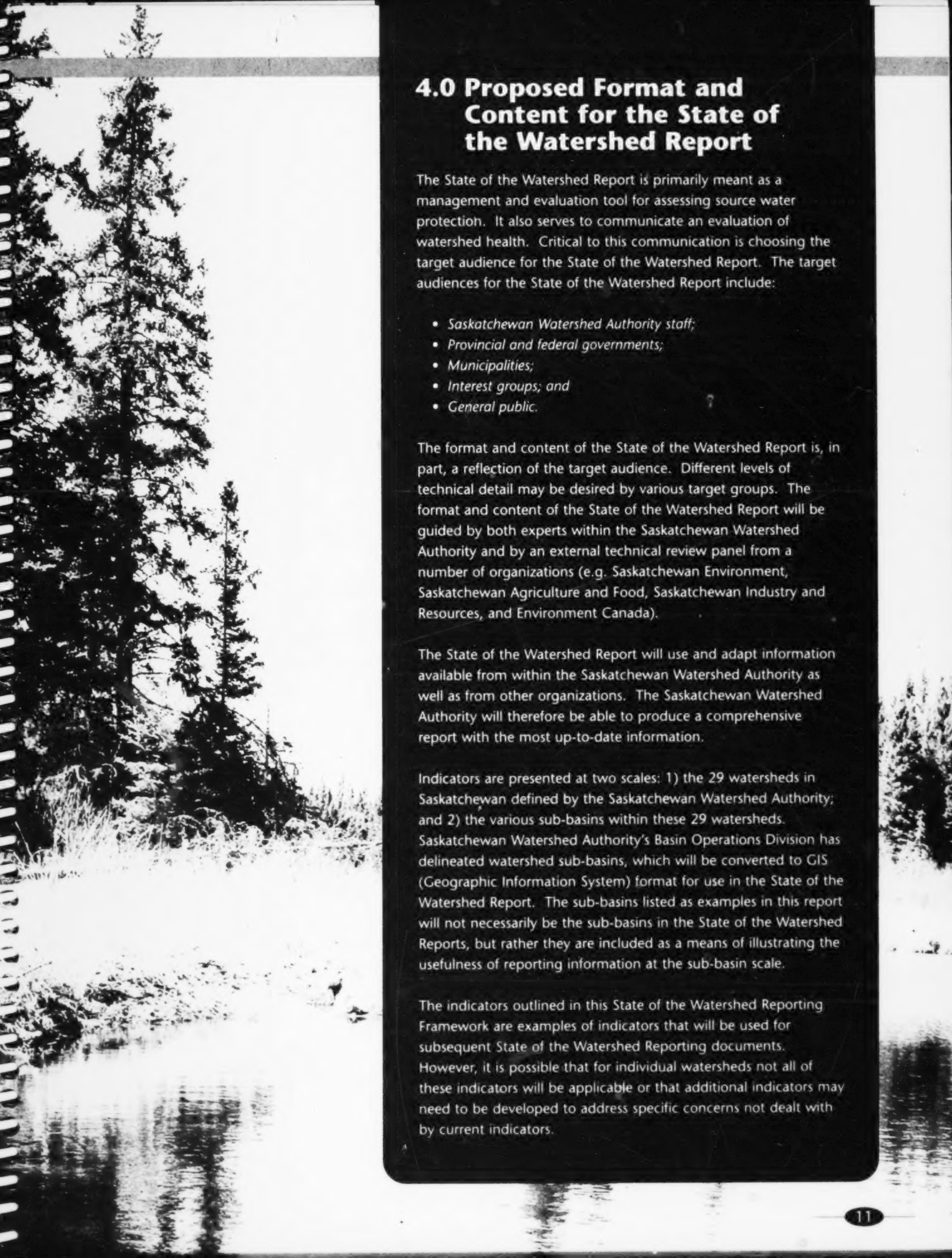
Figure 4. Estimate of permanent cover by watershed.





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I Introduction

The introduction will include a general statement of the Saskatchewan Watershed Authority's mandate, the goals and objectives of the document and its reporting function. This section will also include a background description of the process used to develop the watershed reports, including watershed scale used, indicators used, and technical input and review.

II Description of the Watershed

This section will describe, in general terms, the attributes of the watershed(s) being assessed, e.g. physical environment (geology and soils, climate, water resources, fire), biological environment (micro/macro flora and fauna), and cultural environment (settlement, reserves and Treaty Land Entitlement, demographics, human health and heritage, etc.). Specific challenges or areas of focus will also be identified.

III *Stress-Condition-Response* Indicators

This section will present the indicators of watershed health grouped in the *Stress-Condition-Response* Model. The stressors section will outline how the watershed is used and summarize the magnitude and trend of the major parameters influencing condition. The condition section will indicate the impacts of stressors on watershed health and the capacity of the watershed to buffer those stressors. The response section will outline what we are doing with regard to source water protection and watershed health. The intent is to link watershed management activities by organizations, such as the provincial government, municipalities, and stewardship groups, with the stressors and condition of the watersheds being assessed.

Table 2. *Stress-Condition-Response* indicators and how they relate.

Issue	*Stress Indicators*	*Condition Indicators*	*Response Indicators*
Human settlements	- Human populations - Roads - Aquatic fragmentation - Potential spring runoff from urban impervious areas - Municipal wastewater effluent discharge	- Water Quality Index - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Permanent cover	- Water conservation - Watershed education - Conservation stewards - Stewardship workshops - Watershed planning
Water use	- Surface water allocation - Groundwater allocation	- Surface water quantity - Groundwater quantity - Water Quality Index	- Water conservation - Watershed education - Watershed planning
Agricultural land use	- Livestock operations - Soil erosion - Fertilizer inputs - Pesticide inputs - Manure application	- Water Quality Index - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Permanent cover	- Water conservation - Watershed education - Livestock operations regulations - Conservation stewards - Stewardship workshops - Watershed planning
Industrial land use	- Oil and gas spills - Mining - Forestry	- Water Quality Index - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Permanent cover	- Water conservation - Watershed education - Watershed planning

IV Summary

This section will include a summary of the condition indicators and their associated ratings. Condition indicators are summarized in a chart format and an assessment of the overall watershed health will be provided. Table 3 provides criteria to assign watershed health grades to Stress, Condition, and Response indicators, and Table 4 provides an example of a Watershed Report Card. The ratings given are a reflection of the existing conditions within the watershed and are not an indication of the effectiveness of the response indicators.

Table 3. Criteria to assign watershed health grades to Stress, Condition, and Response indicators.

Stress Indicators	Indicator Descriptions	High stress	Moderate stress	Low stress
Human Population Size	Human population size is the number and distribution of people that reside in Saskatchewan.	> 111, 673 people	31,932 to 111,673 people	< 31,932 people
Numerical Change in Human Population	Numerical change in human population is the change in the number and distribution of people that reside in Saskatchewan between 1991 and 2001.	>3092 people	419 to 3092 people	< 419 people
Human Population Density	Population density is a measurement of the number of people per square kilometre.	> 6.54 people/km²	2.64 to 6.54 people/km2	< 2.64 people/km²
Roads	The roads indicator reports on the percentage of the watershed ecologically impacted by roads.	> 23.9%	9% to 23%	< 9%
Surface Water Allocation	Surface water allocation assesses the percentage of the supply of surface water that is withdrawn from the system.	> 40%	20% to 40%	< 20%
Aquatic Fragmentation	Aquatic fragmentation estimates the potential hydrologic alteration caused by control structures.	> 1.86 barriers/km	1.25 to 1.86 barriers/km	< 1.25 barriers/km
Spring Runoff Potential of Impervious Areas	Potential spring runoff of urban impervious areas estimates the maximum percentage of spring flow that is associated with spring runoff from impervious areas.	> 20%	2% to 20%	< 2%
Livestock Operations	The livestock operations indicator assesses the risk that livestock operations impose to source water.	> 35	18 to 35	< 18
Soil Erosion (tonnes/hectare/year)	Soil erosion is an estimmate of the potential of soil erosion on cropped land caused by precipitation and surface runoff.	> 22	11 to 22	< 11
Fertilizer Inputs	Fertilizer inputs measures the intensity of fertilizer use by watershed between 1986 and 2001.	> $21.09 /hectare	$5.99 to $21.09/hectare	< $5.99 /hectare
Pesticide Inputs	Pesticide inputs measures the intensity of pesticide use by watershed between 1986 and 2001.	> $17.65 /hectare	$6.65 to $17.65 /hectare	< $6.65 /hectare
Density of Oil and Gas Spills	Density of oil and gas spills is a measurement of the number of oil and gas spills per square kilometre over a ten-year period.	> 0.038390 spills/km²	0.006381 and 0.038390 spills/km²	<0.006381 spills/km²
Annual Volume of Oil and Emulsion Spills	Volume of oil and emulsion spills is a measure of the average annual volume of oil and emulsion spills per square kilometre.	> 46 litres	9 to 46 litres/km²	< 9 litres/km²
Annual Volume of Saltwater Spills	Volume of saltwater spills is a measure of the average annual volume of saltwater spills per square kilometre.	> 100 litres/km²	13 to 100 litres/km²	< 13 litres/km²
Condition Indicators		**Impaired**	**Stressed**	**Healthy**
Water Quality Index	The Water Quality Index is an assessment of the chemical and biological constituents within the water.	< 45	45 to 79	80 to 100
Riparian Health	Riparian health measures the ability of a riparian area to perform the essential functions of trapping sediment, filtering runoff, stabilizing streambanks, groundwater recharge, and providing wildlife habitat.	< 60	60 to 79	80 to 100
Riparian Buffer	Riparian buffer is the percent of permanent cover within a 40 m buffer of the adjacent waterway.	0 to 25	25.1 to 72.5	> 72.5
Rangeland Health	Rangeland health measures the ability of a rangeland to perform the essential functions of reducing soil erosion, increasing water infiltration and reducing runoff.	< 50	50 to 74	75 to 100
Permanent Cover	Permanent cover is the percentage of perennial vegetation within southern Saskatchewan watersheds.	< 27%	27% to 46%	> 46%
Response Indicators		**Absent/Gap**		**Present**
Water Conservation	The water conservation indicator reports on the water conservation methods employed within Saskatchewan.	Yes		Yes
Watershed Education	The watershed education indicator reports on number and type of watershed related educational programs delivered at schools.	Yes		Yes
Livestock Operations Regulations	The livestock operations regulations indicator reports on the existing regulations in Saskatchewan.	Yes		Yes
Conservation Stewards	The volunteer stewards indicator reports on the number of volunteer stewards within a watershed.	Yes		Yes
Stewardship Workshops	The stewardship workshops indicator reports on the number of stewardship workshops per watershed.	Yes		Yes
Watershed Planning	The watershed planning indicator assesses the measurable attributes of watershed and aquifer planning.	Yes		Yes

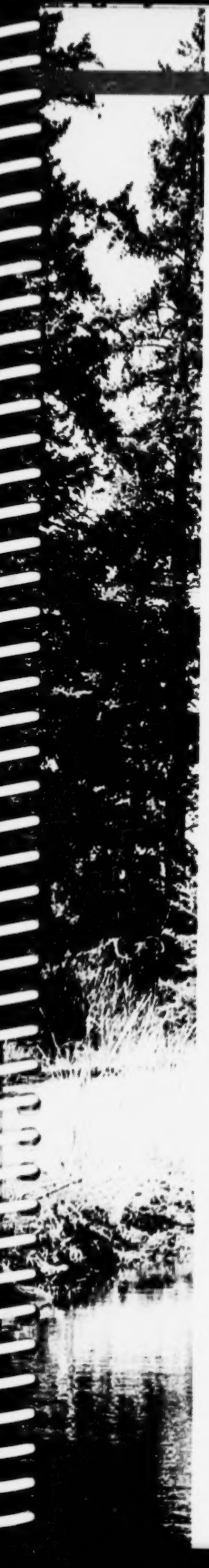


Table 3. Criteria to assign watershed health grades to Stress, Condition, and Response indicators.

Stress Indicators	Indicator Descriptions	High stress	Moderate stress	Low stress
Human Population Size	Human population size is the number and distribution of people that reside in Saskatchewan.	> 111, 673 people		< 31,932 people
Numerical Change in Human Population	Numerical change in human population is the change in the number and distribution of people that reside in Saskatchewan between 1991 and 2001.	> 3092 people		< 419 people
Human Population Density	Population density is a measurement of the number of people per square kilometre.	> 6.54 people/km^2		< 2.64 people/km^2
Roads	The roads indicator reports on the percentage of the watershed ecologically impacted by roads.	> 23.9%		< 9%
Surface Water Allocation	Surface water allocation assesses the percentage of the supply of surface water that is withdrawn from the system.	> 40%		< 20%
Aquatic Fragmentation	Aquatic fragmentation estimates the potential hydrologic alteration caused by control structures.	> 1.86 barriers/km		< 1.25 barriers/km
Spring Runoff Potential of Impervious Areas	Potential spring runoff of urban impervious areas estimates the maximum percentage of spring flow that is associated with spring runoff from impervious areas.	> 20%		< 2%
Livestock Operations	The livestock operations indicator assesses the risk that livestock operations impose to source water.	> 55		< 18
Soil Erosion (tonnes/hectare/year)	Soil erosion is an estimmate of the potential of soil erosion on cropped land caused by precipitation and surface runoff.	> 22		< 11
Fertilizer Inputs	Fertilizer inputs measures the intensity of fertilizer use by watershed between 1986 and 2001.	> $21.09 /hectare		< $5.99 /hectare
Pesticide Inputs	Pesticide inputs measures the intensity of pesticide use by watershed between 1986 and 2001.	> $17.65 /hectare		< $6.65 /hectare
Density of Oil and Gas Spills	Density of oil and gas spills is a measurement of the number of oil and gas spills per square kilometre over a ten-year period.	> 0.038390 spills/km^2		<0.006381 spills/km^2
Annual Volume of Oil and Emulsion Spills	Volume of oil and emulsion spills is a measure of the average annual volume of oil and emulsion spills per square kilometre.	> 46 litres		< 9 litres/km^2
Annual Volume of Saltwater Spills	Volume of saltwater spills is a measure of the average annual volume of saltwater spills per square kilometre.	> 100 litres/km^2		< 13 litres/km^2
Condition Indicators		**Impaired**	**Stressed**	**Healthy**
Water Quality Index	The Water Quality Index is an assessment of the chemical and biological constituents within the water.	< 45		80 to 100
Riparian Health	Riparian health measures the ability of a riparian area to perform the essential functions of trapping sediment, filtering runoff, stabilizing streambanks, groundwater recharge, and providing wildlife habitat.	< 50		80 to 100
Riparian Buffer	Riparian buffer is the percent of permanent cover within a 40 m buffer of the adjacent waterway.	0 to 25		> 72.5
Rangeland Health	Rangeland health measures the ability of a rangeland to perform the essential functions of reducing soil erosion, increasing water infiltration and reducing runoff.	< 50		75 to 100
Permanent Cover	Permanent cover is the percentage of perennial vegetation within southern Saskatchewan watersheds.	< 17%		> 46%
Response Indicators		**Absent/Gap**		**Present**
Water Conservation	The water conservation indicator reports on the water conservation methods employed within Saskatchewan.	Yes		Yes
Watershed Education	The watershed education indicator reports on number and type of watershed related educational programs delivered at schools.	Yes		Yes
Livestock Operations Regulations	The livestock operations regulations indicator reports on the existing regulations in Saskatchewan.	Yes		Yes
Conservation Stewards	The volunteer stewards indicator reports on the number of volunteer stewards within a watershed.	Yes		Yes
Stewardship Workshops	The stewardship workshops indicator reports on the number of stewardship workshops per watershed.	Yes		Yes
Watershed Planning	The watershed planning indicator assesses the measurable attributes of watershed and aquifer planning.	Yes		Yes

Table 4. Example of a Provincial Watershed Report Card with select indicators.

Watershed	Stress Indicators	Human Population Size: 2001	Numerical Change in Human Population: 1991-2001	Human Population Density (people/km2): 2001
Assiniboine River		46,613	-5,904	2.63
Athabasca River		95	15	0.01
Battle River		12,922	-28	1.34
Beaver River		22,418	2,111	0.68
Big Muddy Creek		7,866	-1,485	0.8
Black Lake		760	418	0.02
Carrot River		29,956	2,068	1.71
Churchill River		19,958	3,902	0.2
Cypress Hills North Slope		4,280	-244	0.72
Eagle Creek		24,400	-1,899	1.5
Kasba Lake		27	2	0
Lake Athabasca		1,647	49	0.03
Lake Winnipegosis		14,038	-2,272	0.75
Lower Qu'Appelle River		38,904	-1,560	2.27
Lower Souris River		13,219	-157	1.44
Milk River		4,372	-621	0.31
Moose Jaw River		40,775	-2,458	4.33
North Saskatchewan River		108,163	-3,510	2.87
Old Wives Lake		11,990	-2,420	0.68
Poplar River		2,275	-375	0.73
Quill Lakes		14,166	-1,082	1.61
Reindeer River / Wollaston Lake		1,935	377	0.03
Saskatchewan River		18,588	-368	0.45
South Saskatchewan River		257,542	12,149	6.54
Swift Current Creek		19,730	-40	5.02
Tazin River		19	1	0
Upper Qu'Appelle River		31,931	-2,827	1.63
Upper Souris River		41,461	-2,489	2.06
Wascana Creek		188,228	-229	48.7

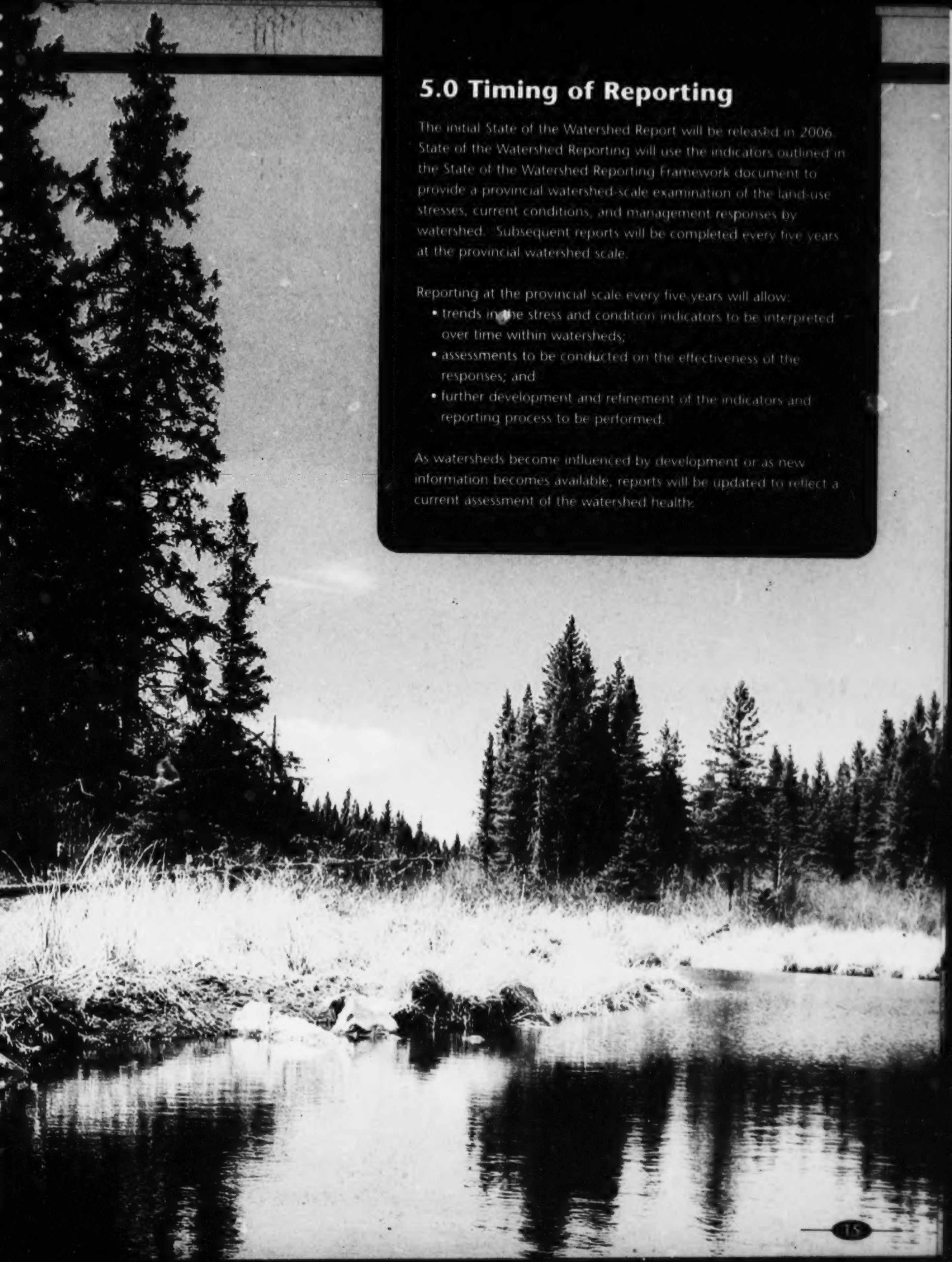
5.0 Timing of Reporting

The initial State of the Watershed Report will be released in 2006. State of the Watershed Reporting will use the indicators outlined in the State of the Watershed Reporting Framework document to provide a provincial watershed-scale examination of the land-use stresses, current conditions, and management responses by watershed. Subsequent reports will be completed every five years at the provincial watershed scale.

Reporting at the provincial scale every five years will allow:

- trends in the stress and condition indicators to be interpreted over time within watersheds;
- assessments to be conducted on the effectiveness of the responses; and
- further development and refinement of the indicators and reporting process to be performed.

As watersheds become influenced by development or as new information becomes available, reports will be updated to reflect a current assessment of the watershed health.



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Athabasca River		95	15	0.01
Battle River		12,922	-28	1.34
Beaver River		22,418		0.60
Big Muddy Creek		7,866	-1,405	0.8
Black Lake		760	418	0.02
Carrot River		29,956		1.71
Churchill River		32,938		0.2
Cypress Hills North Slope		4,280	244	0.72
Eagle Creek		24,400	-1,899	1.5
Kasba Lake		27	2	0
Lake Athabasca		1,647	49	0.03
Lake Winnipegosis		14,038	-2,272	0.75
Lower Qu'Appelle River			-1,560	2.77
Lower Souris River		13,217	-157	1.44
Milk River		4,572	-623	0.31
Moose Jaw River			-2,458	
North Saskatchewan River			3,510	2.87
Old Wives Lake		11,990	-2,420	0.66
Poplar River		2,275	-375	0.73
Quill Lakes		14,166	1,082	1.61
Reindeer River / Wollaston Lake		1,935	372	0.01
Saskatchewan River		18,568	-368	0.43
South Saskatchewan River		257,548	21,188	
Swift Current Creek		19,730	-40	
Tazin River		39	1	0
Upper Qu'Appelle River		31,931	-2,822	1.63
Upper Souris River			-2,489	2.06
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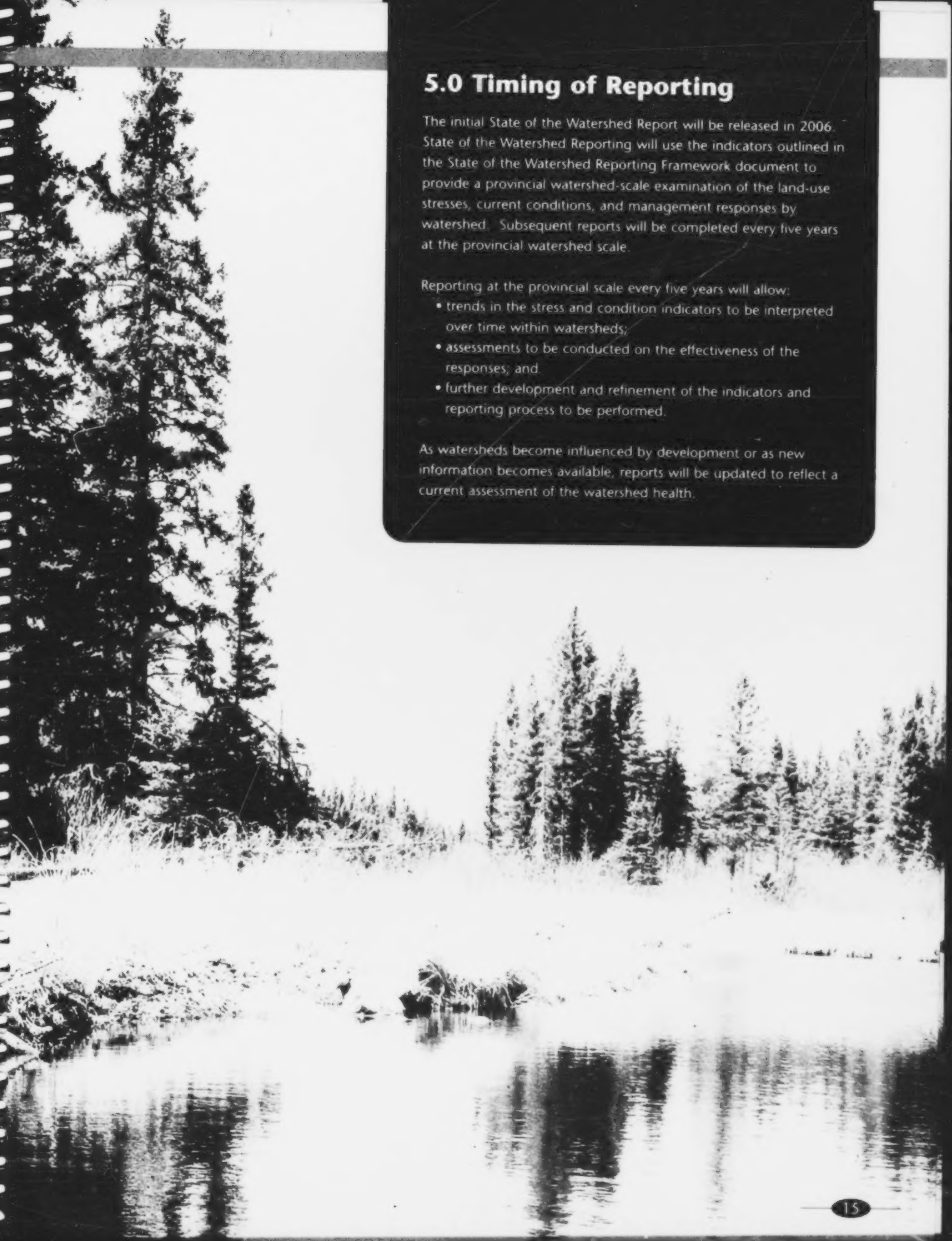

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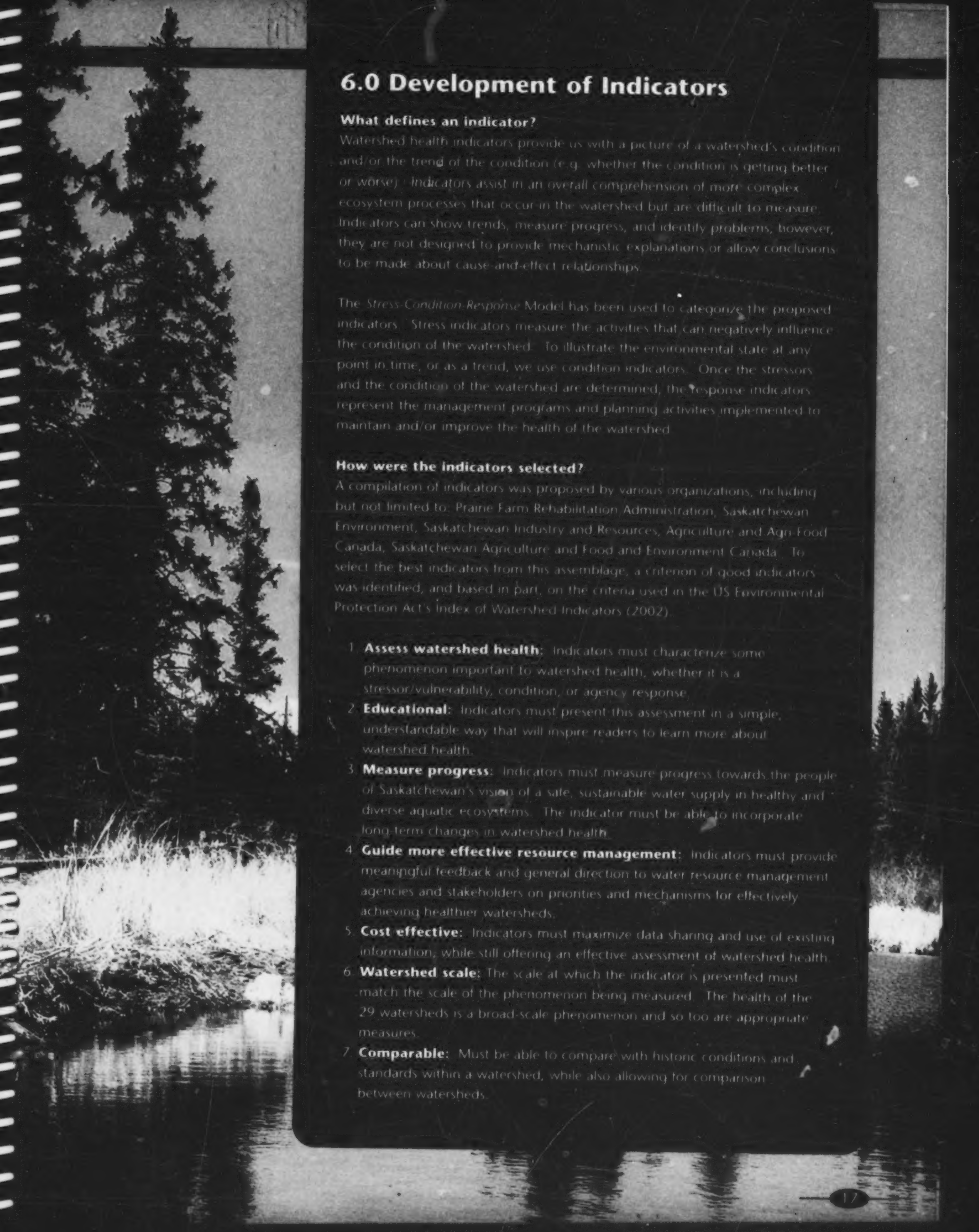
As watersheds become influenced by development or as new information becomes available, reports will be updated to reflect a current assessment of the watershed health.

Photos courtesy of (clockwise from top left): Saskatchewan Industry and Resources, Nature Saskatchewan, Nature Saskatchewan, Swift Current Creek Watershed Stewards, Saskatchewan Agriculture and Food, Saskatchewan Industry and Resources, Saskatchewan Watershed Authority and Nature Saskatchewan.



6.0 Development of Indicators

What defines an indicator?

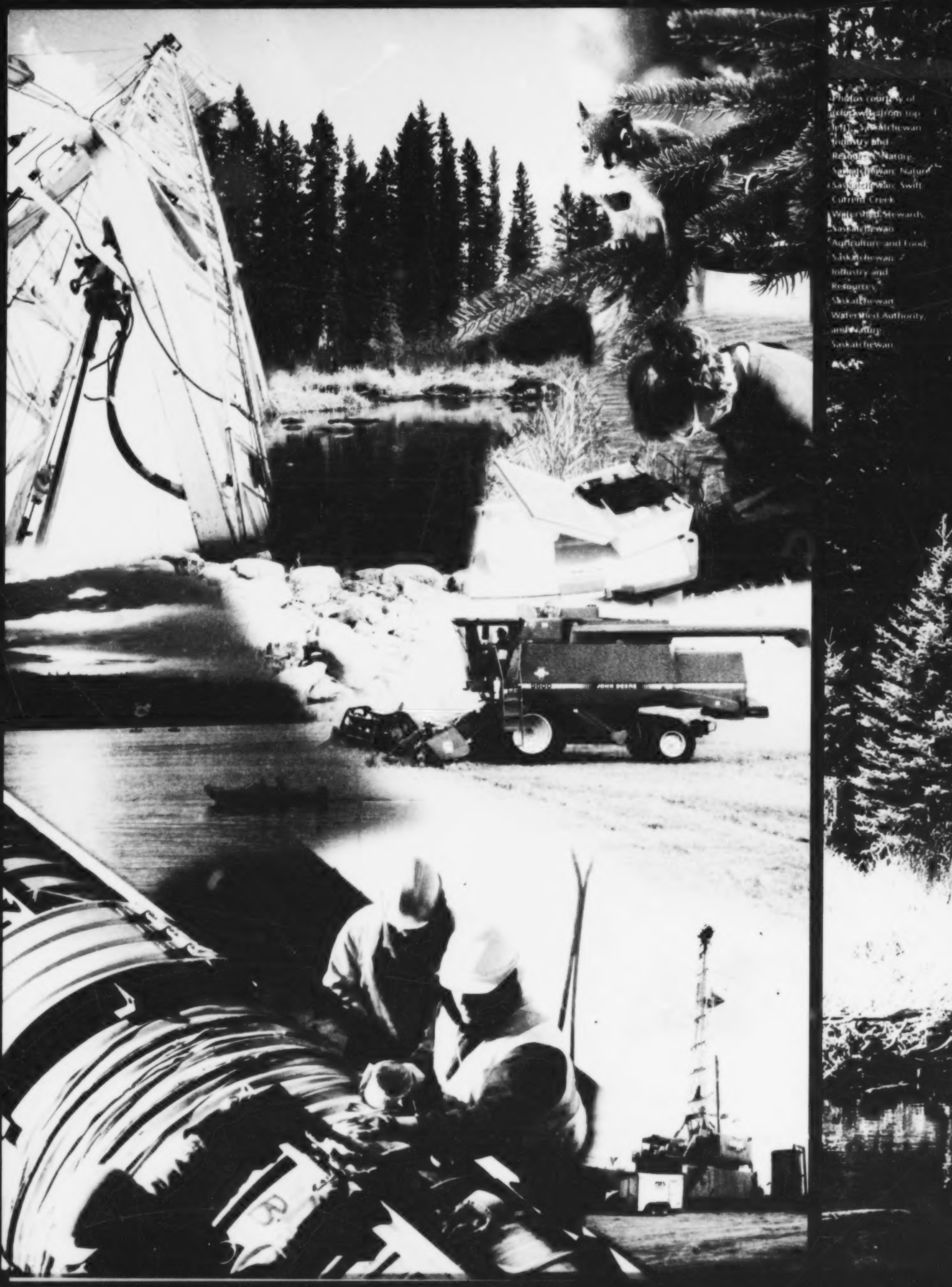
Watershed health indicators provide us with a picture of a watershed's condition and/or the trend of the condition (e.g. whether the condition is getting better or worse). Indicators assist in an overall comprehension of more complex ecosystem processes that occur in the watershed but are difficult to measure. Indicators can show trends, measure progress, and identify problems, however, they are not designed to provide mechanistic explanations or allow conclusions to be made about cause-and-effect relationships.

The *Stress-Condition-Response* Model has been used to categorize the proposed indicators. Stress indicators measure the activities that can negatively influence the condition of the watershed. To illustrate the environmental state at any point in time, or as a trend, we use condition indicators. Once the stressors and the condition of the watershed are determined, the response indicators represent the management programs and planning activities implemented to maintain and/or improve the health of the watershed.

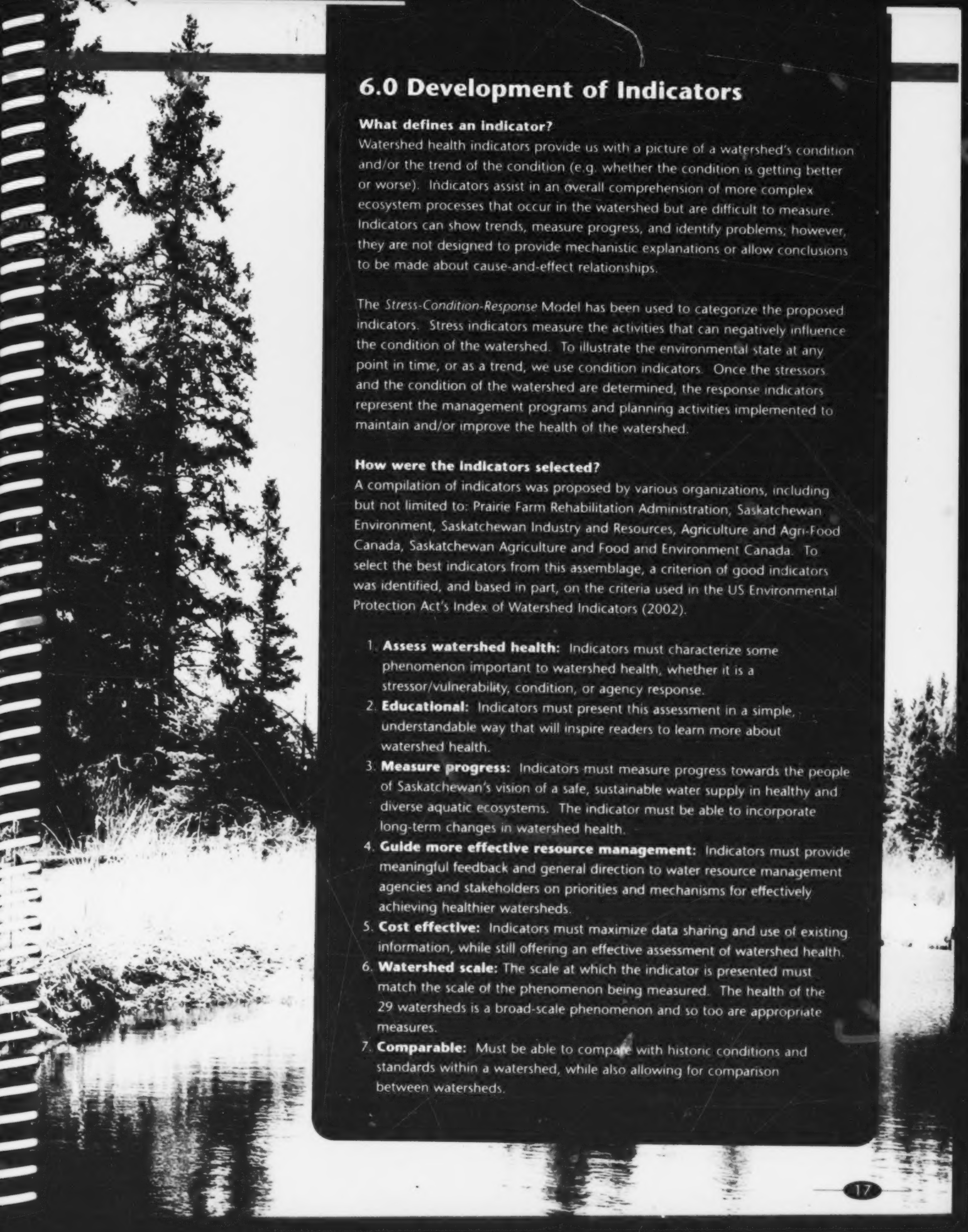
How were the indicators selected?

A compilation of indicators was proposed by various organizations, including but not limited to: Prairie Farm Rehabilitation Administration, Saskatchewan Environment, Saskatchewan Industry and Resources, Agriculture and Agri-Food Canada, Saskatchewan Agriculture and Food and Environment Canada. To select the best indicators from this assemblage, a criterion of good indicators was identified, and based in part, on the criteria used in the US Environmental Protection Act's Index of Watershed Indicators (2002).

1. **Assess watershed health:** Indicators must characterize some phenomenon important to watershed health, whether it is a stressor/vulnerability, condition, or agency response.
2. **Educational:** Indicators must present this assessment in a simple, understandable way that will inspire readers to learn more about watershed health.
3. **Measure progress:** Indicators must measure progress towards the people of Saskatchewan's vision of a safe, sustainable water supply in healthy and diverse aquatic ecosystems. The indicator must be able to incorporate long-term changes in watershed health.
4. **Guide more effective resource management:** Indicators must provide meaningful feedback and general direction to water resource management agencies and stakeholders on priorities and mechanisms for effectively achieving healthier watersheds.
5. **Cost effective:** Indicators must maximize data sharing and use of existing information, while still offering an effective assessment of watershed health.
6. **Watershed scale:** The scale at which the indicator is presented must match the scale of the phenomenon being measured. The health of the 29 watersheds is a broad-scale phenomenon and so too are appropriate measures.
7. **Comparable:** Must be able to compare with historic conditions and standards within a watershed, while also allowing for comparison between watersheds.



Photos courtesy of (clockwise from top left): Saskatchewan Industry and Resources, Nature Saskatchewan, Nature Saskatchewan, Swift Current Creek Watershed Stewards, Saskatchewan Agriculture and Food, Saskatchewan Industry and Resources, Saskatchewan Watershed Authority, and Nature Saskatchewan



6.0 Development of Indicators

What defines an indicator?

Watershed health indicators provide us with a picture of a watershed's condition and/or the trend of the condition (e.g. whether the condition is getting better or worse). Indicators assist in an overall comprehension of more complex ecosystem processes that occur in the watershed but are difficult to measure. Indicators can show trends, measure progress, and identify problems; however, they are not designed to provide mechanistic explanations or allow conclusions to be made about cause-and-effect relationships.

The *Stress-Condition-Response* Model has been used to categorize the proposed indicators. Stress indicators measure the activities that can negatively influence the condition of the watershed. To illustrate the environmental state at any point in time, or as a trend, we use condition indicators. Once the stressors and the condition of the watershed are determined, the response indicators represent the management programs and planning activities implemented to maintain and/or improve the health of the watershed.

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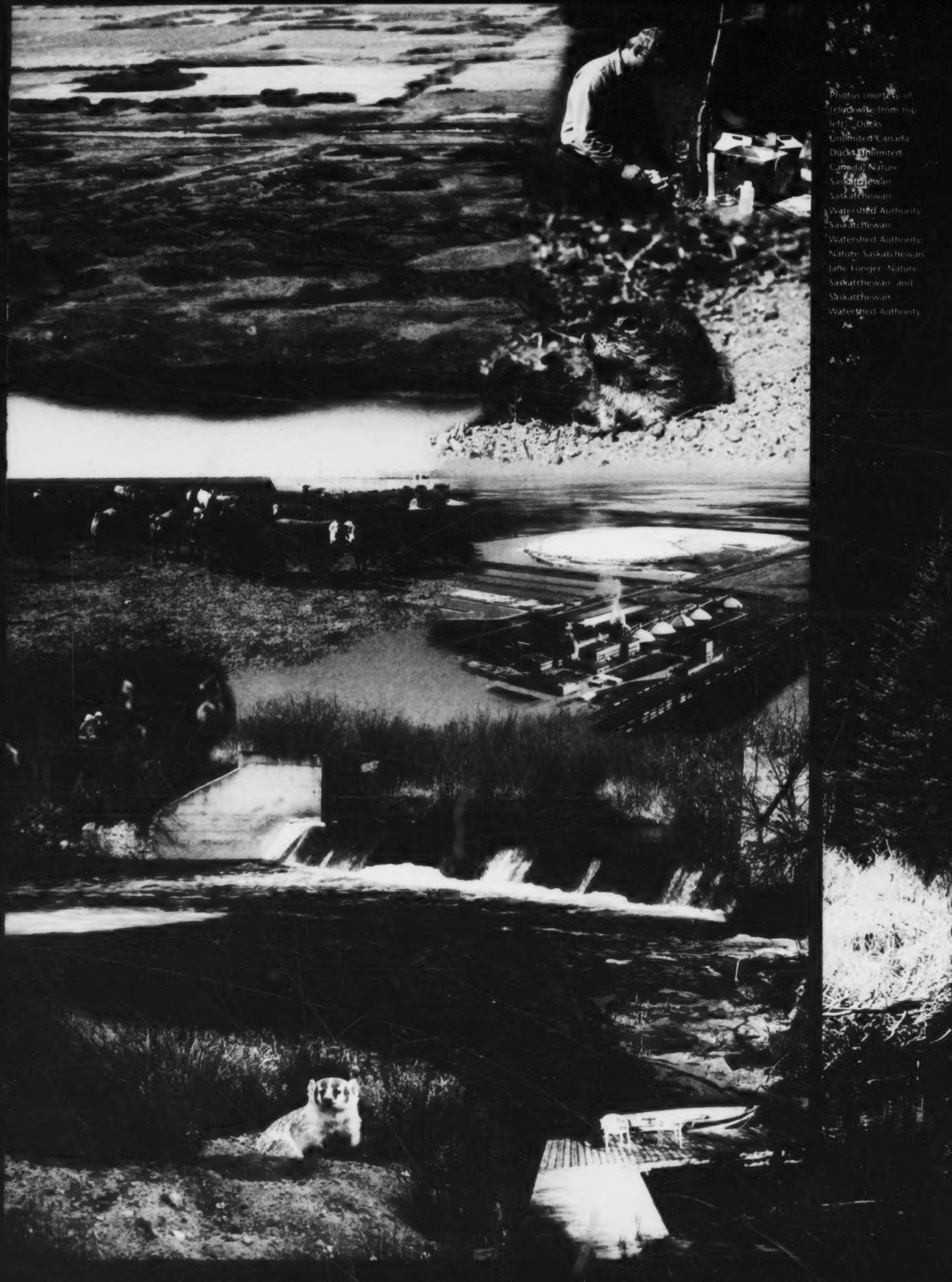
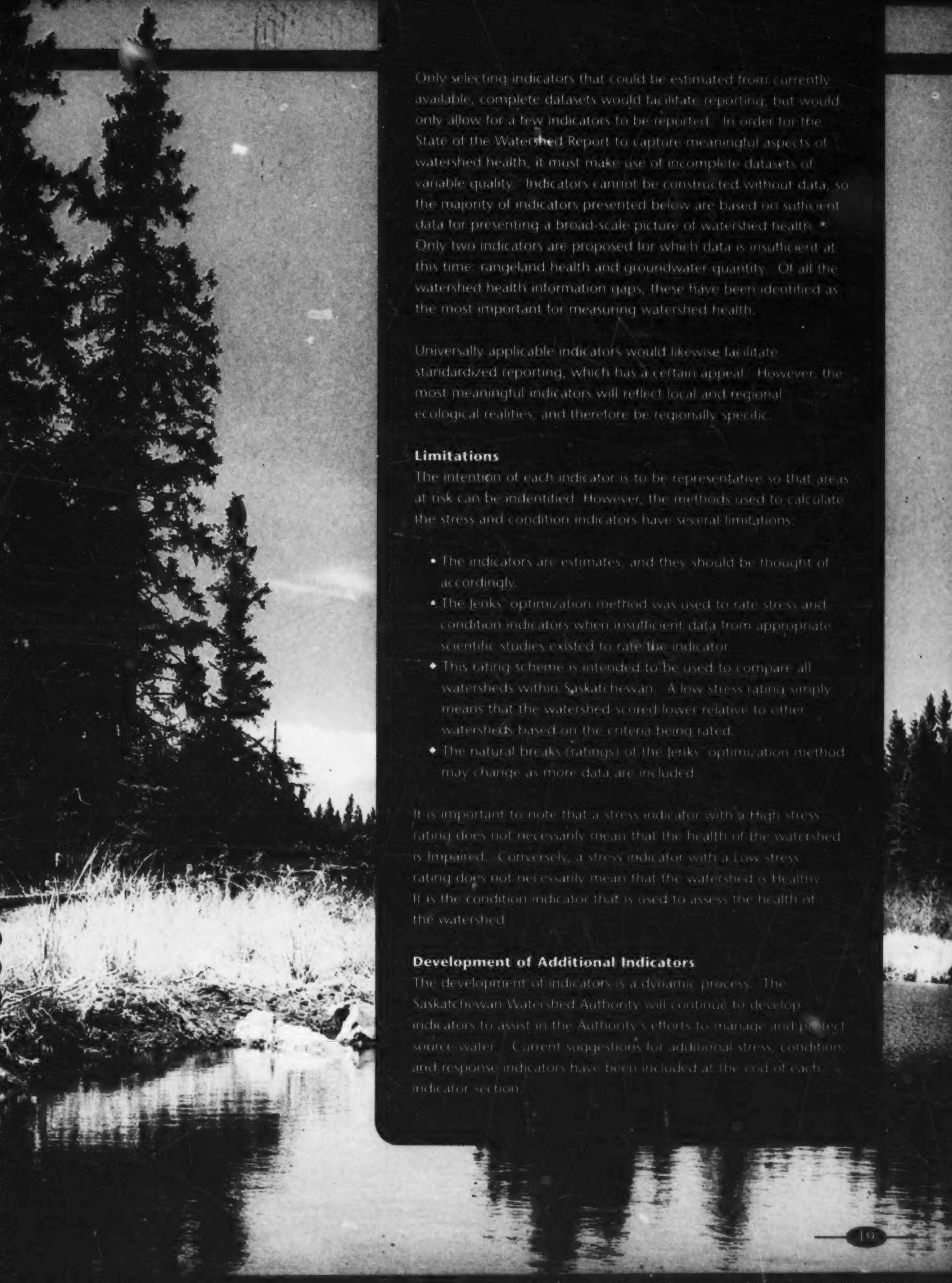


Photos courtesy of (clockwise from top left): Ducks Unlimited Canada, Ducks Unlimited Canada, Nature Saskatchewan, Saskatchewan Watershed Authority, Saskatchewan Watershed Authority, Nature Saskatchewan, Jane Fonger, Nature Saskatchewan, and Saskatchewan Watershed Authority



Only selecting indicators that could be estimated from currently available, complete datasets would facilitate reporting, but would only allow for a few indicators to be reported. In order for the State of the Watershed Report to capture meaningful aspects of watershed health, it must make use of incomplete datasets of variable quality. Indicators cannot be constructed without data, so the majority of indicators presented below are based on sufficient data for presenting a broad-scale picture of watershed health. Only two indicators are proposed for which data is insufficient at this time: rangeland health and groundwater quantity. Of all the watershed health information gaps, these have been identified as the most important for measuring watershed health.

Universally applicable indicators would likewise facilitate standardized reporting, which has a certain appeal. However, the most meaningful indicators will reflect local and regional ecological realities, and therefore be regionally specific.

Limitations

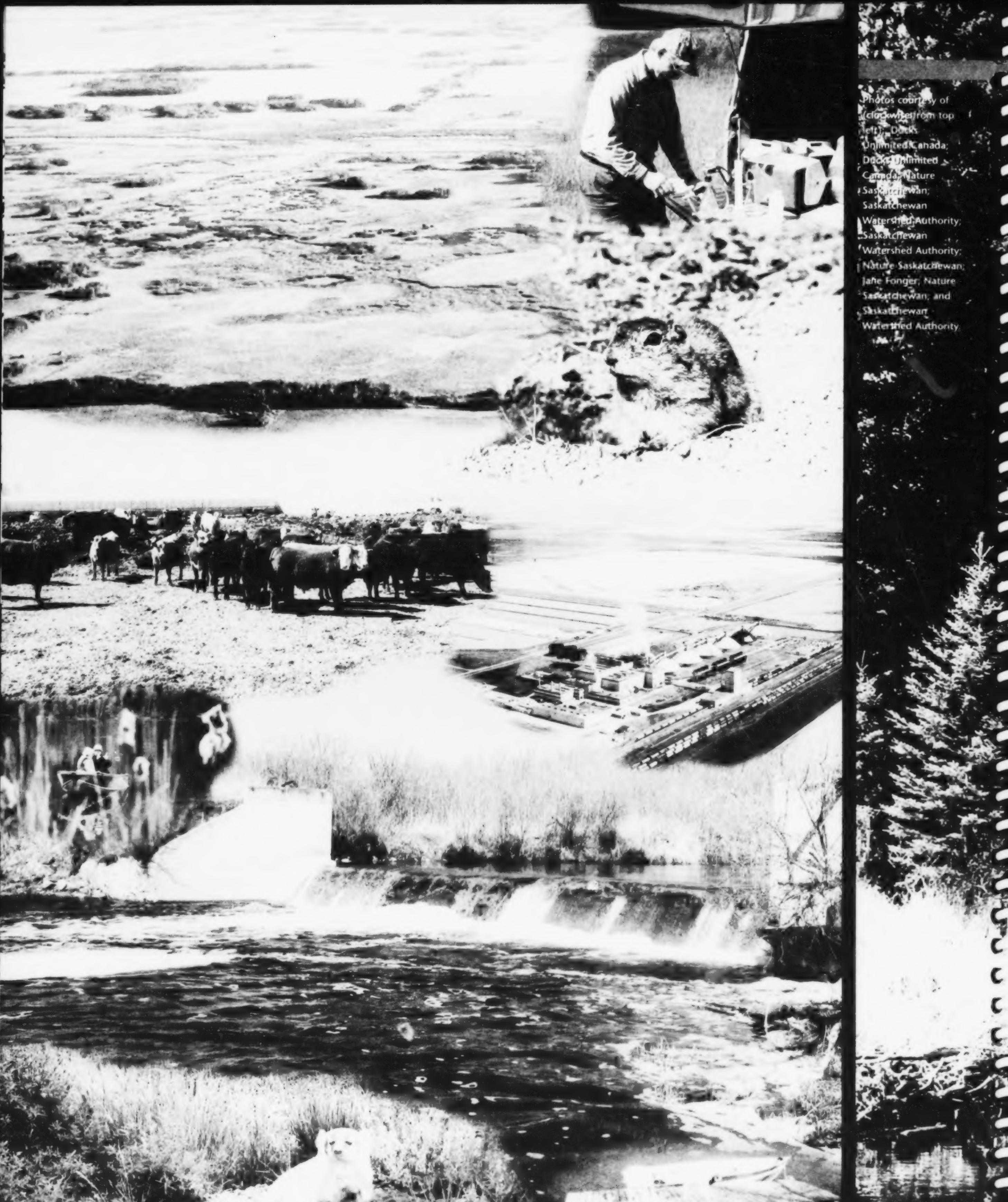
The intention of each indicator is to be representative so that areas at risk can be indentified. However, the methods used to calculate the stress and condition indicators have several limitations:

- The indicators are estimates, and they should be thought of accordingly.
- The Jenks' optimization method was used to rate stress and condition indicators when insufficient data from appropriate scientific studies existed to rate the indicator.
- This rating scheme is intended to be used to compare all watersheds within Saskatchewan. A low stress rating simply means that the watershed scored lower relative to other watersheds based on the criteria being rated.
- The natural breaks (ratings) of the Jenks' optimization method may change as more data are included.

It is important to note that a stress indicator with a High stress rating does not necessarily mean that the health of the watershed is Impaired. Conversely, a stress indicator with a Low stress rating does not necessarily mean that the watershed is Healthy. It is the condition indicator that is used to assess the health of the watershed.

Development of Additional Indicators

The development of indicators is a dynamic process. The Saskatchewan Watershed Authority will continue to develop indicators to assist in the Authority's efforts to manage and protect source-water. Current suggestions for additional stress, condition, and response indicators have been included at the end of each indicator section.



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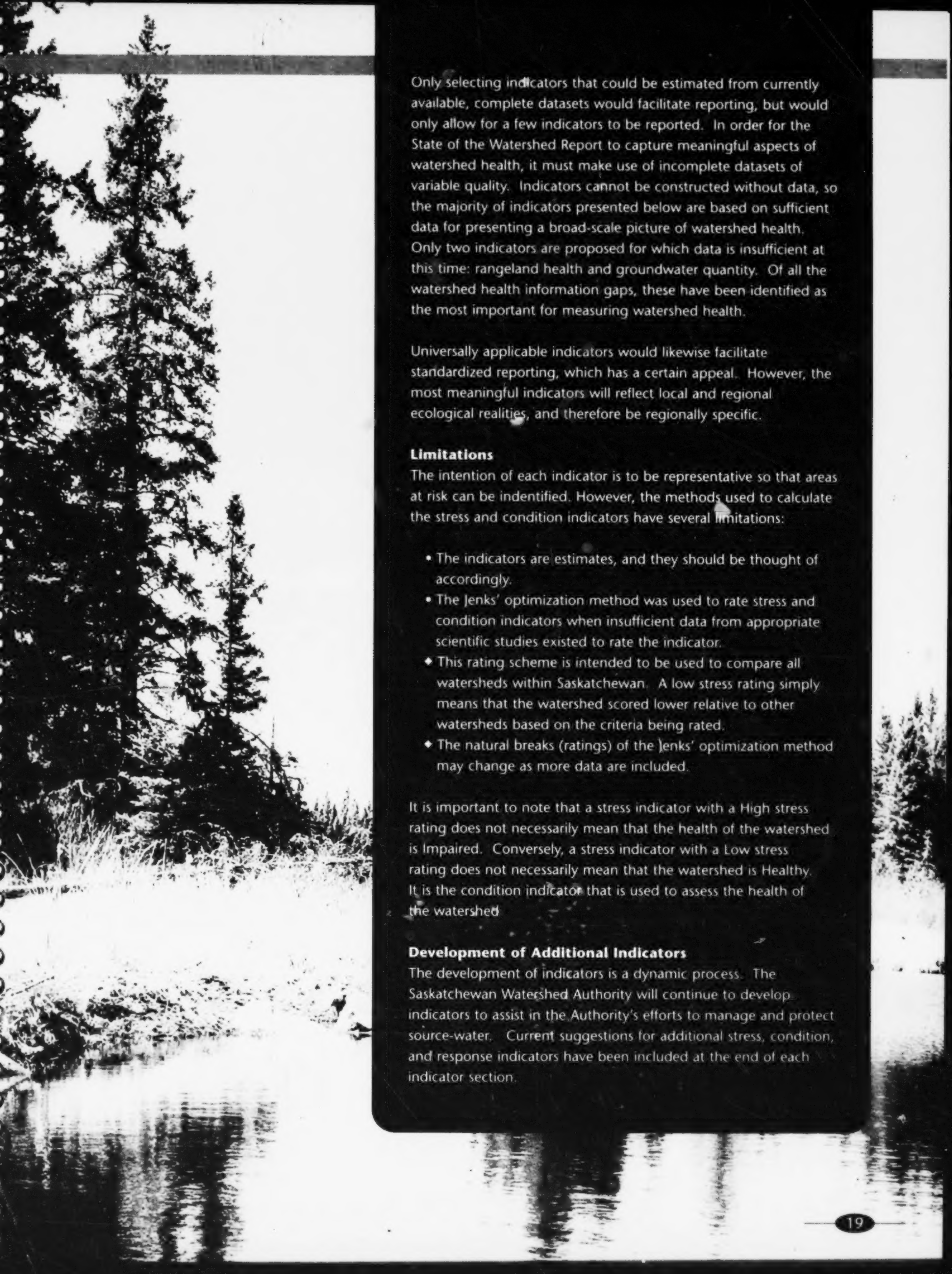

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Photos courtesy of (clockwise from top left): Saskatchewan Watershed Authority; Nature Saskatchewan; Nature Saskatchewan; Saskatchewan Industry and Resources; Ducks Unlimited Canada; Saskatchewan Agriculture and Food; Saskatchewan Watershed Authority; Wawryk Associates Ltd.; and Nature Saskatchewan.

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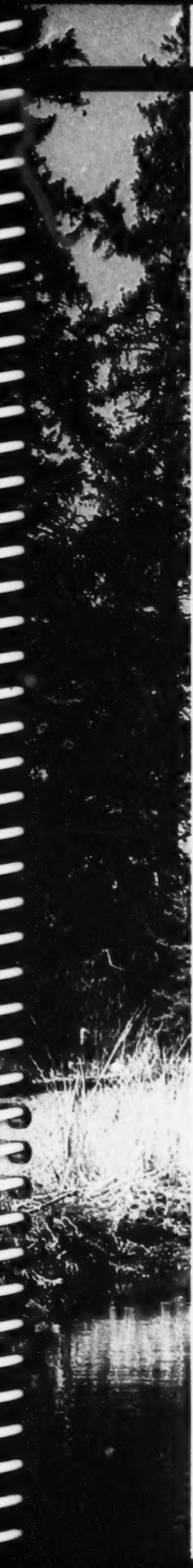

7.0 Indicators

This section outlines the indicators that have been developed for assessing watershed health using the *Stress-Condition-Response* Model.

7.1 Stress Indicators

Human Population Indicator

What is this indicator, and why is it important?
This indicator reports on trends in population density, population change and regional distribution within the watersheds.

Increases in human population often result in increased demands for infrastructure, such as housing, water, energy, transportation and waste disposal. In order to accommodate population growth and to provide the necessary infrastructure there must be accompanying land-use changes and other potential environmental impacts that can impact on water quantity and quality (Environment Protection Authority, New South Wales 2003).

Humans are not simply stressors with only negative impacts on environmental quality; they frequently are responsible stewards of natural resources. Humans are a dominant driver of ecological structure and function; in many cases humans are the most important influence (Pimm 2001). Human population density obviously does not in itself cause environmental deterioration. However, it serves as a proxy for many mechanisms that do.

Measure: The population indicator describes human population growth rate, density trends, and regional distribution within Saskatchewan's 29 watersheds.

$$\text{Population Change} = \frac{\text{Population}_{t1} - \text{Population}_{t0}}{\text{Population}_{t0}}$$

$$\text{Population Density} = \frac{\text{Population within a watershed}}{\text{Watershed area (km}^2\text{)}}$$

The population by watershed is the spatially weighted Census Subdivision (CSD) population (see Appendix, Figure 33).

Rating Scheme:
Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Population Size

Low Stress – Population in the watershed is between 18 and 31,931 people.

Moderate Stress – Population in the watershed is between 31,932 and 111,673 people.

High Stress – Population in the watershed is more than 111,673 people.

Numerical Change in Population

Low Stress – Change in population where there is a loss in population up to an additional 418 people immigrating into the watershed.

Moderate Stress – Change in population where there are between 419 and 3,902 people immigrating into the watershed.

High Stress – Change in population where there are more than 3,902 people immigrating into the watershed.

Population Density

Low Stress – Population density in the watershed is less than 2.64 people/km^2.

Moderate Stress – Population density in the watershed is between 2.64 and 6.54 people/km^2.

High Stress – Population density in the watershed is greater than 6.54 people/km^2.

Data:

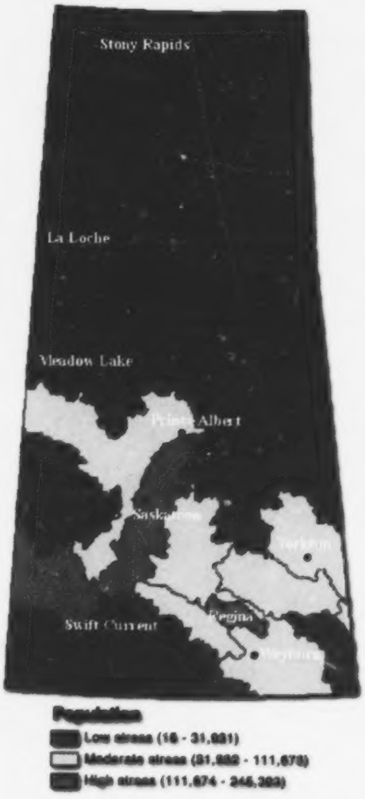
Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Swift Current
Weyburn
Population
Low stress (18 - 31,931)
Moderate stress (31,932 - 111,673)
High stress (111,674 - 245,393)

Figure 5. Human population by watershed: 1991.

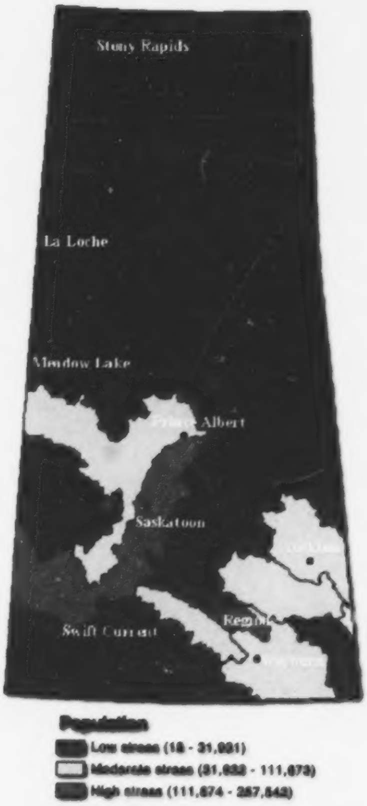
Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Swift Current
Weyburn
Population
Low stress (18 - 31,931)
Moderate stress (31,932 - 111,673)
High stress (111,674 - 257,542)

Figure 6. Human population by watershed: 2001.

Table 5 shows an example of sub-basin populations estimated using census blocks in the Souris River basin.

Table 5. Souris River Basin population by sub-basin.

Sub-basin	Population
Antler River	5,216
Four Creeks	2,021
Lanigan Creek	2,021
Long Creek	2,122
Moose Mountain Creek	9,202
Pipestone Creek	5,415
Souris River	32,508

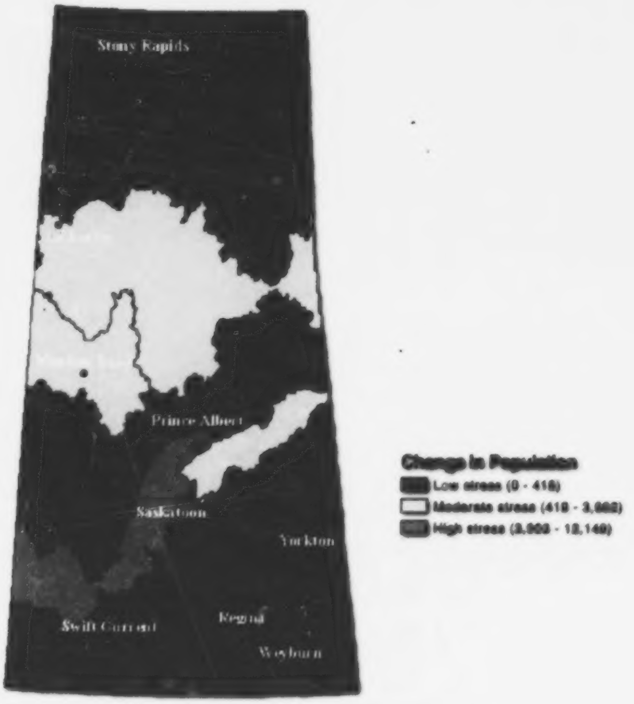
Stony Rapids
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Change in Population
Low stress (0 - 418)
Moderate stress (419 - 3,882)
High stress (3,883 - 12,149)

Figure 7. Numerical change in the human population by watershed: 1991 to 2001.

Population Size

Low Stress – Population in the watershed is between 18 and 31,931 people.

Moderate Stress – Population in the watershed is between 31,932 and 111,673 people.

High Stress – Population in the watershed is more than 111,673 people.

Numerical Change in Population

Low Stress – Change in population where there is a loss in population up to an additional 418 people immigrating into the watershed.

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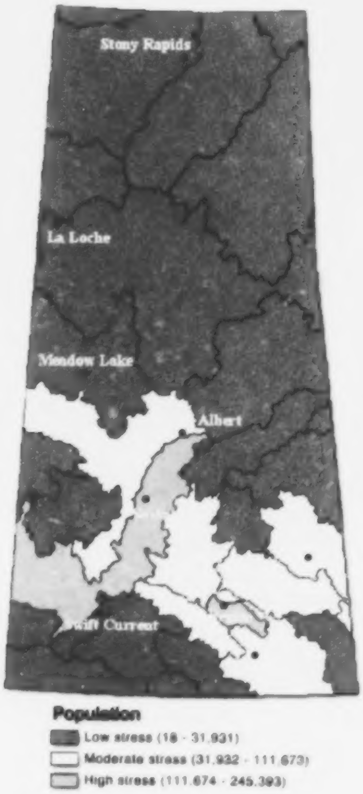
Stony Rapids
La Loche
Meadow Lake
Albert
wift Current
Population
▨ Low stress (18 - 31,931)
☐ Moderate stress (31,932 - 111,673)
▨ High stress (111,674 - 245,393)

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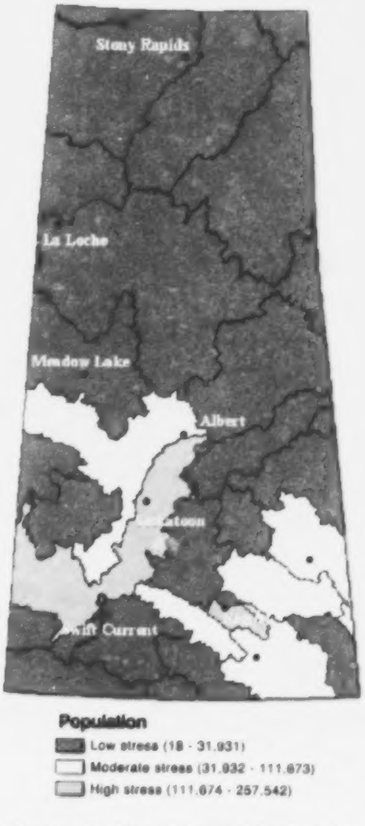
Stony Rapids
La Loche
Meadow Lake
Albert
wift Current
Population
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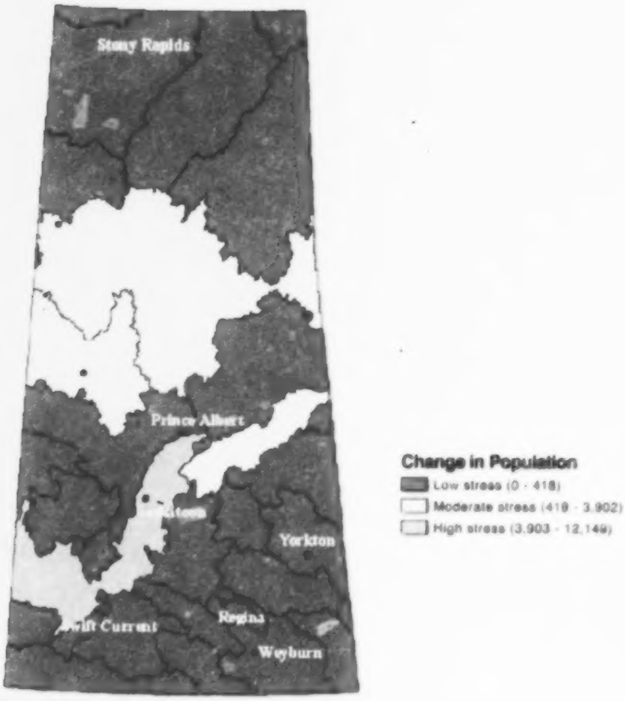

Stony Rapids
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Change in Population
Low stress (0 - 418)
Moderate stress (419 - 3,902)
High stress (3,903 - 12,149)

Figure 7. Numerical change in the human population by watershed: 1991 to 2001.

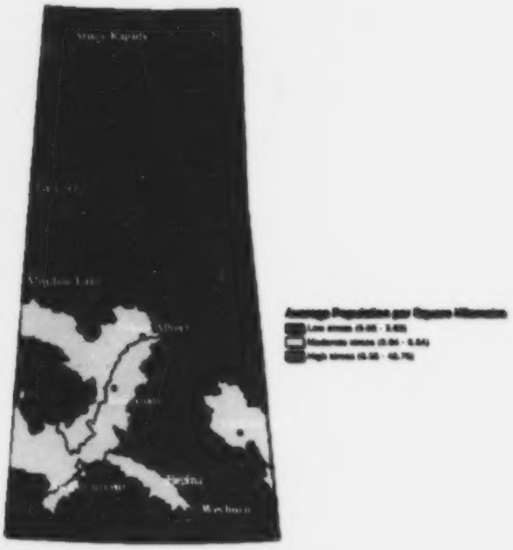


Figure 8. Population density by watershed: 1991.

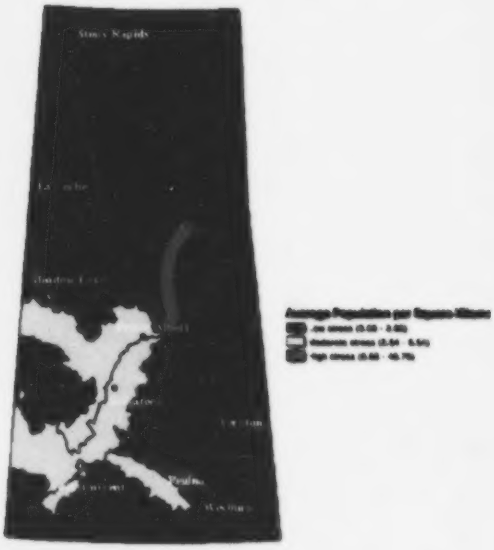


Figure 9. Population density by watershed: 2001.

Data Source: Population data was obtained from the 2001 Census of Canada (Statistics Canada 2002b).

Data Handling: This measure requires the Statistics Canada census by blocks or Census Sub-Division (CSD).

Blocks were used to estimate 2001 population for the following watersheds and sub-basins: Assiniboine River, Big Muddy Creek, Cypress Hills North Slope, Lower Qu'Appelle River, Lower Souris River, Milk River, Moose Jaw River, Old Wives Lake, Swift Current Creek, Upper Souris River, and Wascana Creek Watersheds; and Antler River, Four Creeks, Lanigan Creek, Long Creek, Moose Mountain Creek, Pipestone Creek, and Souris River Sub-basins.

The 2001 population for the remaining watersheds and sub-basins was estimated by CSD.

Data Discussion: Decadal scales are appropriate for assessing temporal watershed population changes. Previous census data would help determine the long-term trend for Saskatchewan. The pre-1991 censuses may be available only at the CSD level. Currently, the Saskatchewan Watershed Authority has access to 1981 population census data but has not acquired previous data. Population census in 1971 may be available in digital format; however, all years prior to 1971 are published and may be represented on a provincial scale only. The Saskatchewan Bureau or Legislative building will have published information for years previous to 1971, while not charging the fee that Statistics Canada does. Sub-basin populations could also be estimated using census blocks.

Discussion: The total population of Saskatchewan in 2001 was approximately 978,278 people. This is a decline of 8,876 people since 1991. Two of the most populated watersheds are the Wascana Creek and the South Saskatchewan River, where the cities of Regina and Saskatoon are found respectively. The Upper Qu'Appelle River Watershed is the only watershed where the human population is in a different stress category between 1991 (Figure 5) and 2001 (Figure 6). The Upper Qu'Appelle River Watershed had a population of 34,758 in 1991 and in 2001 the population was 31,931 people. Population change between 1991 and 2001 was greatest for the South Saskatchewan River and Churchill River Watersheds, which grew by 12,149 and 3,902 people respectively. Wascana Creek Watershed was the most densely populated with 48.75 people per square kilometre in 1991 and 48.70 people per square kilometre in 2001. The Assiniboine River Watershed is the only watershed where the human population density is found in a different stress category between 1991 (Figure 8) and 2001 (Figure 9). The population density of the Assiniboine River Watershed was 2.97 people/km^2 in 1991 and 2.63 people/km^2 in 2001.

Road Indicator

What is this indicator, and why is it important?

This indicator will report on the percentage of the watershed ecologically impacted by roads.

Roads can have physical, chemical, and biological effects on aquatic ecosystems. Roads affect the physical processes of aquatic ecosystems by altering flow regimes, and increasing soil erosion, water runoff, sediment deposition, and turbidity (Forman and Alexander 1998). Roads affect the chemical processes of aquatic ecosystems through the transport of pollutants through runoff. The biological impacts of roads include alteration of habitat and habitat connectivity (Angermeier et al. 2004). Forman and Deblinger (2000) found that various ecological effects of roads extend from at least 100 m to more than 1 km from the road.

Measure: The *Road Effect Zone* (REZ) is a method proposed by Forman et al. (1997) to estimate the area ecologically affected by roads. Road Effect Zone Density is the measure of road effects within a watershed.

$$\text{Road Effect Zone Density} = \frac{\text{Road Effect Zone (km}^2\text{)}}{\text{Total watershed area (km}^2\text{)}} \times 100$$

Assumption:

1) Road Effect Zone is weighted by road class, with roads classified into primary and secondary roads. A 300 m buffer for primary roads and 200 m buffer for secondary roads is proposed (Forman 2000). Various arguments can be made for revising these buffer distances upwards, downwards, or even not using buffers. The aim was simply to give more weight to wider, more heavily-used roads.

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find natural breaks in the Saskatchewan data.

Road Effect Zone Density

Low Stress - Road effect zone density in the watershed is less than 9%.

Moderate Stress – Road effect zone density in the watershed is between 9% and 23%.

High Stress – Road Effect Zone in the watershed is greater than 23.9%.

Data:

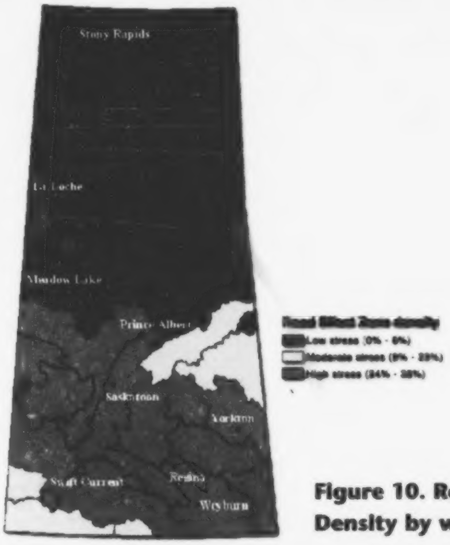


Figure 10. Road Effect Zone Density by watershed.

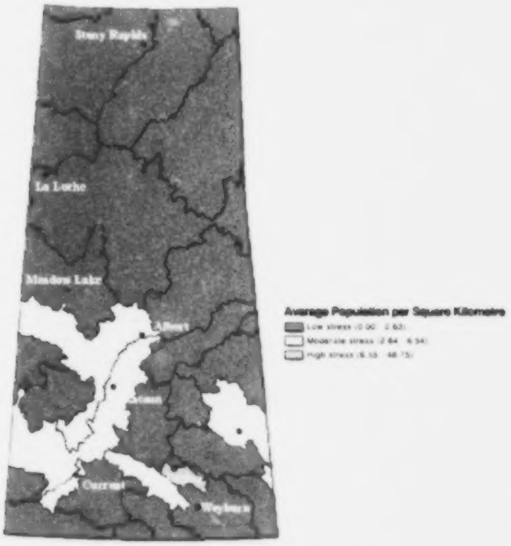
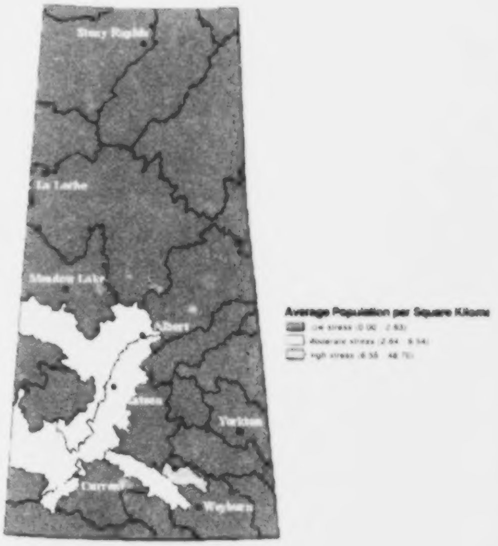

Stony Rapids
La Loche
Meadow Lake
Albert
Current
Weyburn
Average Population per Square Kilometre
Low stress (0.00 - 2.63)
Moderate stress (2.64 - 6.54)
High stress (6.55 - 48.75)

Figure 8. Population density by watershed: 1991.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Assumption:

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Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find natural breaks in the Saskatchewan data.

Road Effect Zone Density
Low Stress - Road effect zone density in the watershed is less than 9%.
Moderate Stress – Road effect zone density in the watershed is between 9% and 23%.
High Stress – Road Effect Zone in the watershed is greater than 23.9%.

Data:

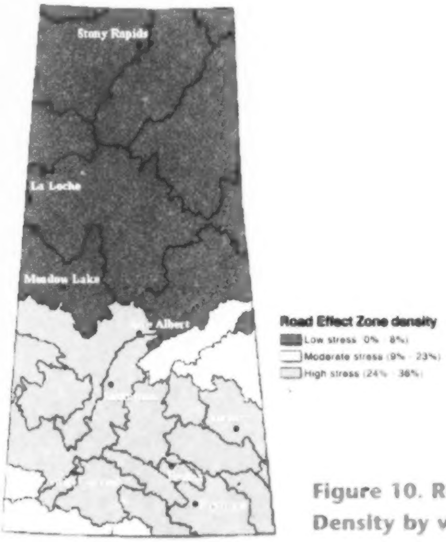


Figure 10. Road Effect Zone Density by watershed.

Data Source: Road density information was obtained from the National Road Network file.

Data Discussion: Insufficient data from appropriate scientific studies existed to rate this indicator. However, a small number of studies have identified road density thresholds. Road Density (road kilometres/square kilometres) is commonly used in the scientific literature. Road densities above thresholds have the potential to negatively affect various wildlife species, for example:

- 1.24 km/km^2 caused grizzly bears to be significantly displaced;
- 1.25 km/km^2 caused black bears to be significantly displaced;
- 0.62 km/km^2 adversely affected elk; and
- Road densities of less than 0.28 km/km^2 supported strong bull trout populations. Bull trout populations were found to decrease when the road density was 0.87 km/km^2 or greater, and bull trout populations are typically absent when road densities are 1.06 km/km^2 (Hammer 2003 and British Columbia Ministry of Water, Land, and Air Protection 2002).

Discussion: The Road Effect Zone Density indicator categorizes 15 of the 29 watersheds as being of under High stress potential. The size of the human population within the watershed, the size of the watershed, and the location of the watershed in the province are all factors that influence the Road Effect Zone Density. Watersheds in the northern portion of the province have a very low Road Effect Zone Density and are placed in the Low stress category. Most of the watersheds in the southern portion of the province are in the High stress category. The three southern watersheds that are not in the High stress category are the only watersheds in Southern Saskatchewan with populations fewer than 5,000 people.

Water Uses

Monitoring surface and groundwater use is important to any water conservation strategy and to general water management, especially for allocation in drier areas. The economic sectors in Saskatchewan that use the most water include agricultural (irrigation and livestock) and community (municipalities and individuals), which, respectively, withdraw 67% and 21% of the freshwater used in this province (Saskatchewan Watershed Authority 2004).

Surface Water Allocation Indicator

What is this indicator, and why is it important?

The Surface Water Allocation indicator assesses the supply of surface water available after allocation and natural losses. Allocation is the volume of water licensed by the project that the project is allowed to withdraw.

Measure:

$$\text{Surface Water Allocation Ratio} = \frac{\text{Diversion (dam}^3\text{)}}{\text{Supply (dam}^3\text{)}} \times 100$$

- *Diversion* is the licensed amount of allocation added to the loss, where the loss represents volume lost due to evaporation and groundwater recharge.
- *Supply* is measured using the estimated calculated median annual flow.

Rating Scheme:

The surface water allocation rating scheme takes into consideration instream flow needs and the Prairie Provinces Water Board's 1969 Master Agreement on Apportionment. Under this agreement, if a watershed is part of an international or interprovincial basin the Province of Saskatchewan must provide 50% of the estimated median annual flow to the receiving jurisdiction.

Surface Water Allocation

Low Stress - Surface water allocation and losses are less than 20% of the supply.

Moderate Stress – Surface water allocation and losses are between 20% and 40% of the supply.

High Stress – Surface water allocation and losses are greater than 40% of the supply.

Data:

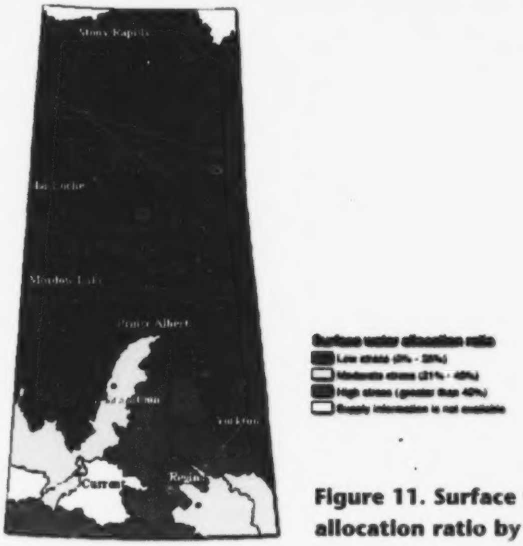

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Swift Current
Surface water allocation ratio
Low stress (0% - 20%)
Moderate stress (21% - 40%)
High stress (greater than 40%)
Supply information is not available

Figure 11. Surface water allocation ratio by watershed.

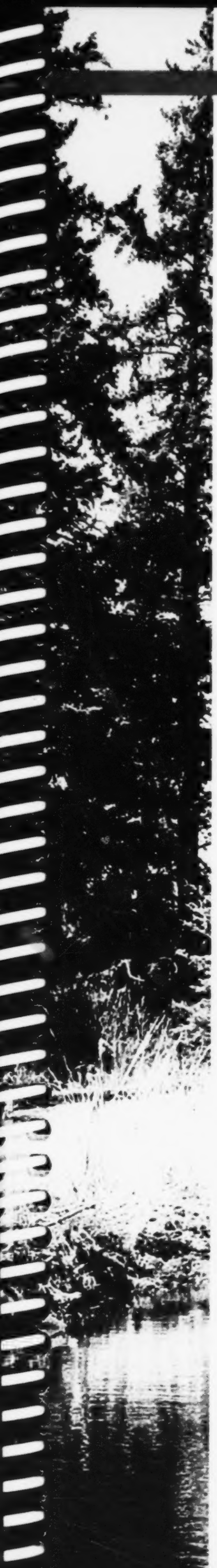
Data Source: Allocation and loses were obtained from Saskatchewan Watershed Authority's Surface Water Allocation Database. Supply is the estimated median annual flow for each major watershed basin (Saskatchewan Watershed Authority 2004).

Data Quality/Caveats: Each year approximately 100 million cubic metres are diverted from the South Saskatchewan River to the Qu'Appelle Basin (which includes the Upper and Lower Qu'Appelle River, Moose Jaw River, Wascana Creek, and Quill Lakes Watersheds). This diversion makes up the difference between the water losses and supply in the Qu'Appelle Basin. Therefore, the supply in the Qu'Appelle Basin is actually 223 million cubic metres, instead of 123 million cubic metres. If the surface water allocation ratio were calculated with the supply of 223 million cubic metres the surface water allocation ratio would be 25.38%, instead of 46.02%. This would change the stress in the respective watersheds from High to Moderate.

Data Discussion: Available data does not allow calculation of water use. Instead, what is proposed is to determine the ratio of allocation to supply. Allocation and usage are not synonymous: allocation refers to the volume of water that a project is allowed to withdraw; usage refers to the volume that is actually withdrawn. Actual water use may be greater or less than that allocated.

Discussion:

Most of the watersheds in Saskatchewan, with the exception of the Qu'Appelle Basin (which includes the Upper and Lower Qu'Appelle River, Moose Jaw River, Wascana Creek, and Quill Lakes Watersheds) and the Missouri Basin (which includes the Milk River, Poplar River, and Big Muddy Creek Watersheds) currently have a surface water allocation ratio of less than 25%.



Rating Scheme:

The surface water allocation rating scheme takes into consideration instream flow needs and the Prairie Provinces Water Board's 1969 Master Agreement on Apportionment. Under this agreement, if a watershed is part of an international or interprovincial basin the Province of Saskatchewan must provide 50% of the estimated median annual flow to the receiving jurisdiction.

Surface Water Allocation

Low Stress - Surface water allocation and losses are less than 20% of the supply.

Moderate Stress – Surface water allocation and losses are between 20% and 40% of the supply.

High Stress – Surface water allocation and losses are greater than 40% of the supply.

Data:

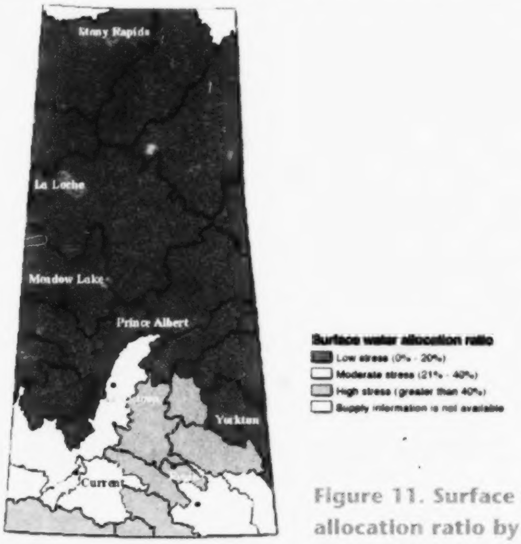

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Yorkton
Current
Surface water allocation ratio
Low stress (0% - 20%)
Moderate stress (21% - 40%)
High stress (greater than 40%)
Supply information is not available

Figure 11. Surface water allocation ratio by watershed.

Data Source: Allocation and loses were obtained from Saskatchewan Watershed Authority's Surface Water Allocation Database. Supply is the estimated median annual flow for each major watershed basin (Saskatchewan Watershed Authority 2004).

Data Quality/Caveats: Each year approximately 100 million cubic metres are diverted from the South Saskatchewan River to the Qu'Appelle Basin (which includes the Upper and Lower Qu'Appelle River, Moose Jaw River, Wascana Creek, and Quill Lakes Watersheds). This diversion makes up the difference between the water losses and supply in the Qu'Appelle Basin. Therefore, the supply in the Qu'Appelle Basin is actually 223 million cubic metres, instead of 123 million cubic metres. If the surface water allocation ratio were calculated with the supply of 223 million cubic metres the surface water allocation ratio would be 25.38%, instead of 46.02%. This would change the stress in the respective watersheds from High to Moderate.

Data Discussion: Available data does not allow calculation of water use. Instead, what is proposed is to determine the ratio of allocation to supply. Allocation and usage are not synonymous: allocation refers to the volume of water that a project is allowed to withdraw; usage refers to the volume that is actually withdrawn. Actual water use may be greater or less than that allocated.

Discussion:

Most of the watersheds in Saskatchewan, with the exception of the Qu'Appelle Basin (which includes the Upper and Lower Qu'Appelle River, Moose Jaw River, Wascana Creek, and Quill Lakes Watersheds) and the Missouri Basin (which includes the Milk River, Poplar River, and Big Muddy Creek Watersheds) currently have a surface water allocation ratio of less than 25%.

Groundwater Allocation Indicator

What is this indicator, and why is it important?
This indicator reports on the groundwater allocation by geologic formation. Groundwater is an integral component of the hydrologic cycle with the health of watersheds and various associated ecosystems being dependent on groundwater.

Understanding human groundwater use is important to determine the potential impact on the health and supply of groundwater (Rutherford 2004). Groundwater is extracted for a number of purposes, including domestic, industrial, municipal, irrigation, and dewatering (e.g. pumping water out of a mine). Through an assessment of groundwater yield a comparison can be made between the annual allocation rates and the amount of groundwater available for use. There are few aquifer systems (such as the Regina and Yorkton areas) where there are reasonable estimates of the well yield because of the intensive data collection and analysis requirement in the calculations.

Measure:

Groundwater Allocation = Annual approved groundwater allocation for projects (dam^3)

Data:

Table 6. Annual groundwater allocation by geologic formation.

Formation	Annual groundwater allocation for projects at the application stage (dam^3)	Annual groundwater allocation for projects at the approval to construct stage (dam^3)	Annual groundwater allocation for projects that are approved for operation/licensed (dam^3)
Athabasca	0	0	1,845
Bearpaw	0	0	555
Blairmore	118	0	19,765
Cypress	0	0	62
Deadwood	0	0	123
Devonian	0	0	0
Duperow	0	0	202
Empress	0	0	21,189
French/white/east	795	0	132
Glacial	154	189	76,372
Glacial (Condie)	0	0	437
Glacial (Northern)	0	0	2,255
Glacial (Regina)	0	0	7,173
Glacial (Zehner)	1	0	5,170
Judith	0	37	8,840
Jurassic	0	0	529
Lea Park	0	0	92
Mississippian	0	0	507
Other	0	0	84
Ravenscrag	0	0	2,597
Ribstone	0	0	2,489
Roseray	0	0	598
Viking	0	0	10
Unknown	0	0	16
*	135	1,225	680
Total	**1,203**	**1,451**	**151,721**

* Aquifer has not been identified

Table 7. Annual groundwater allocation by use category.

Purpose	Annual allocation (dam^3)	Percent of annual allocation
Industrial	78,872	51.09%
Municipal	70,462	45.64%
Irrigation	2,542	1.65%
Other	2,394	1.55%
Domestic*	76	0.05%
Multi-purpose	29	0.02%
Total allocation	**154,375**	

* Domestic wells are not pursuant to the *Saskatchewan Watershed Authority Act* and do not require approval for the groundwater works unless the water is used away from the home quarter. The annual domestic allocation of 76 cubic decametres listed in Table 7 was for wells located away from the home quarter, which required an approval.

Approximately 440 municipalities (including cities, towns, First Nation Reserves, and Rural Municipalities) rely on groundwater for Municipal Purposes. The population for these 440 municipalities that rely on groundwater is estimated at 325,211 people, or 33% of Saskatchewan's population.

Data Source: Groundwater extraction allocation data was obtained from Saskatchewan Watershed Authority's Licensed Ground Water Database on August 2, 2005. Population data was obtained from the online Saskatchewan Health Covered Population 2004 report published by Government of Saskatchewan (2004) (http://www.health.gov.sk.ca/mc_dp_covpop2004/main.htm).

Data Handling: Data on the population of cities, towns, First Nation Reserves and Rural Municipalities reliant on groundwater was imported into MS Access and linked to 2004 Saskatchewan Health data (Government of Saskatchewan 2004). When 2004 Saskatchewan Health data was unavailable for the city, town, First Nation Reserve or Rural Municipality, population information was obtained from older Saskatchewan Health data, or Statistics Canada (Statistics Canada 2002b).

Data Quality/Caveats: The Basin and Sub-basin fields in the Licensed Ground Water Database are based on the drainage boundaries, not geologic formation boundaries. A comparison of the watershed and drainage basin map boundaries needs to be conducted to determine the allocation information for a watershed.

Annual groundwater allocation is the amount of groundwater allowable for extraction, it is not the actual amount the project uses. Actual annual extraction information is not often reported, and therefore it is not included in the Licensed Ground Water Database. Groundwater allocations from domestic wells within the home quarter are not included in Table 7. Domestic wells are not pursuant to the *Saskatchewan Watershed Authority Act* and do not require approval for the groundwater works unless the water is used away from the home quarter.

Data Discussion: At present the population reliant on groundwater is summarized for the whole province.

Discussion: A total of 154,375 dam^3 are allocated, or are in the approval process, from groundwater annually. Fifty-nine percent of the groundwater allocations are from the glacial aquifers. The largest volume of groundwater allocated annually is for the industrial sector, at a rate of 78,872 cubic decametres, which includes 29,025 dam^3 of saline water.

Aquatic Fragmentation Indicator

What is this indicator, and why is it important?
This indicator estimates the potential hydrologic alteration caused by control structures, such as dams, weirs, drop structures, and other man-made systems that modify hydrologic flow. Upstream and downstream waterbodies can be ecologically impacted by control structures because of altered flow regimes, altered biogeochemical cycles, changes in water temperature, altered riparian communities, and habitat and migration patterns of fish and other aquatic species (Dynesius and Nillson 1994).

According to the World Commission on Dams (2000) flow pattern is the most important factor affecting the structure and integrity of downstream aquatic ecosystems. The Commission found that aquatic communities in rivers with a naturally variable flow are typically very different than those communities in highly regulated flow. Another significant impact of dams is that they impede the migration and dispersal of aquatic species. Research has found that localized extinction of some freshwater organisms can be directly linked to aquatic fragmentation caused by dams (Gehrke et al. 2002).

Measure: *Aquatic Fragmentation* is estimated by calculating the number of aquatic barriers in a watershed and dividing the number of barriers by the length of streamcourse in that watershed.

Weighting was used to capture the relative difference in impacts between the various forms of aquatic barriers with dams predicted to have the most impact, and bridges and surface water projects the least.

$$\text{Aquatic Fragmentation} = \frac{(3 \times \text{\# of dams}) + (2 \times \text{\# of stream-road crossings}) + (2 \times \text{\# of low-level crossings}) + (\text{\# of bridges})}{\text{Length of waterway (km)}}$$

Stream-road crossings are not known physical barriers; rather they represent the number of intersections between the Saskatchewan National Road Network and the Saskatchewan Stream Network and the number of intersections between the railroads file and the Saskatchewan Stream Network. There will be some redundancy between the stream-road crossing parameter and the other parameters used in this calculation.

Rating Scheme:
Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Aquatic Fragmentation
Low Stress - Aquatic fragmentation is less than 1.25 barriers/km.
Moderate stress – Aquatic fragmentation indicator is between 1.25 and 1.86 barriers/km.
High stress – Aquatic fragmentation indicator is greater than 1.86 barriers/km.

Data:

Table 8. Aquatic fragmentation in the Upper Qu'Appelle and Assiniboine Rivers.

Sub-basin	Dams	Stream-road crossings	Low-level crossings	Bridges	Weighted sum of barriers	Length (km)	Aquatic fragmentation (Barriers/km)
Assiniboine River	90	3,988	11	16	8,404	4,525	1.83
Rousay Lake	4	1,167	0	7	2,406	1,143	2.06
Whitesand River	35	5,785	7	13	11,825	5,292	2.21
Assiniboine Total	**129**	**10,940**	**18**	**36**	**22,635**	**10,960**	**2.04**
Arm River	32	236	3	1	625	671	0.86
Lanigan Creek	37	582	0	6	1,332	1,227	1.04
Last Mountain Lake	109	910	0	4	2,274	2,137	1.01
Little Manitou Lake	47	258	0		729	453	1.45
Upper Qu'Appelle River	179	1,102	0	2	2,922	2,359	1.16
Upper Qu'Appelle Total	**404**	**3,088**	**3**	**13**	**7,882**	**6,847**	**1.08**

Data Source: Dam locations are from the National Topographic Database and the land location of Saskatchewan Watershed Authority's dams. The Saskatchewan Stream Network was used to intersect with roads and railroads to estimate the number of stream-road crossings. Saskatchewan Highways and Transportation databases were used for low-level crossings and bridges.

Data Discussion: Future analysis is dependant on the availability of data and will, therefore, be a function of when the databases are updated; however, the possibility of using previous National Topographic System information with the land locations of structures could provide temporal analysis.

Discussion: This indicator could be refined. Fish passage may be more impeded by main-stem barriers; weighting these more heavily than barriers on lower-order streams is a possibility. With information from organizations such as Fisheries and Oceans Canada, we may be able to attain more detailed information on barriers at a local scale.

In the future, this indicator will hopefully be tied to a direct measure of hydrologic alteration, e.g. some variation of Indicators of Hydrologic Alteration (Richter et al. 1996) that does not require such an extensive pre-alteration hydrologic time series.

There is considerable value in presenting information at a finer scale than sub-basin or for Saskatchewan Watershed Authority's 29 watersheds. In many cases the data does not justify a fine resolution indicator or the high-level indicator is inappropriate for application to finer scales. However, this indicator could be graphically presented by river reach with available data.

Potential Spring Runoff from Urban Impervious Areas Indicator

What is this indicator, and why is it important?

This indicator estimates the maximum percentage of spring flow that is associated with spring runoff from urban impervious areas. *Urban* is defined as a community that has a minimum population concentration of 1,000 people and a population density of at least 400 people per square kilometre (Statistics Canada 1991a). Impervious surfaces include roads, parking lots, sidewalks, driveways and roofs.

Approximately 64% of Saskatchewan's population resides in urban areas (Statistics Canada 2002b). As the urban population grows there is increasing demand to develop infrastructure such as roads and housing, thereby increasing impervious areas. Runoff associated with impervious areas can negatively impact the health of the watershed, because it can: 1) increase the volume and velocity of runoff, causing changes in watershed hydrology, and 2) increase pollutant loadings, which affects the water quality of the watershed. Possible impacts associated with changes in hydrology include flooding, aquatic habitat degradation and the displacement of aquatic species. Pollutants in stormwater runoff can have harmful effects on drinking water supplies, recreational use and wildlife. Some of the ubiquitous urban stormwater pollutants include sediments, motor oil, nutrients from fertilizers and pet waste, microbes, toxic metals, and various organic compounds such as herbicides and pesticides.

Urban runoff water quality studies have previously been conducted for the City of Saskatoon (Munch and Keller 1985; and McLeod et al. 2004). During the summers of 2001 and 2002, McLeod et al. (2004) found concentrations of cadmium, chromium, copper, iron, lead, and zinc in Saskatoon's urban runoff to exceed Canadian Council of Ministers of the Environment's protection of freshwater aquatic life guidelines.

Schueler (1994) reviewed studies examining the relationship between urbanization and stream quality. He found that once drainage basins have more than ten percent impervious area there is often: 1) an increase in the volume of surface runoff; 2) an alteration of stream banks due to increased flows and erosion; and 3) a decrease in aquatic habitat quality resulting in declines in fish and aquatic insect diversity.

Measure:

$$\text{Potential Spring Runoff for Urban Impervious Areas} = \text{Urban impervious area (m}^2\text{)} \times \text{Precipitation (m)}$$

$$\text{Percentage of Spring Flow Associated with Spring Runoff} = \frac{\text{Potential spring runoff for urban impervious areas (m}^3\text{)}}{\text{Spring flow (m}^3\text{)}} \times 100$$

- The impervious cover of the major urban cities (>5,000 people) in Saskatchewan was estimated to be 35%, which is a conservative estimate (Perkins 2004).
- Precipitation data used is from the months of October to the end of May.
- Spring flow data is calculated for the months of March until the end of May.

Assumptions:

- All winter precipitation is effective in producing runoff.
- Observed precipitation at meteorological stations is equal to the precipitation within the urban area.

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Potential Spring Runoff From Urban Impervious Areas

Low Stress - Percentage of spring flow potentially associated with spring runoff is less than 2%.

Moderate Stress – Percentage of spring flow potentially associated with spring runoff is between 2 and 20%.

High Stress – Percentage of spring flow potentially associated with spring runoff is greater than 20%.

Data:

Table 9. Potential spring runoff from impervious areas of major cities as a percentage of spring flow.

Watershed	Major city	Spring runoff as a percent of 1999 spring flow	Spring runoff as a percent of 2000 spring flow	Spring runoff as a percent of 2001 spring flow	Spring runoff as a percent of 2002 spring flow	Spring runoff as a percent of 2003 spring flow	Spring runoff as an average percent of spring flow 1999-2003
Assiniboine River	Yorkton	5-10%	50-60%	5-10%	70-80%	15-20%	**30-40%**
South Saskatchewan River	Saskatoon	1-5%	< 1%	1-5%	<1%	<1%	**< 1%**
Wascana Creek	Regina	10-15%	60-70%	5-10%	40-50%	15-20%	**30-40%**

Data Source: The areas for the urban centres were obtained from Saskatchewan Environment's Cadastr file using the Urban Municipalities layer. Precipitation data was obtained from Environment Canada's online climate data (http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html). Flow data was obtained from Water Survey of Canada (http://www.wsc.ec.gc.ca/). Hydrometric flow data for the City of Yorkton is from the Water Survey of Canada (2005), Station ID: 05MB001 (Yorkton Creek near Ebenezer). Hydrometric flow data for the City of Saskatoon is from the Water Survey of Canada (2005), Station ID: 05HG001 (South Saskatchewan River at Saskatoon). Hydrometric flow data for the City of Regina is from the Water Survey of Canada (2005), Station ID: 05JF005 (Wascana Creek near Lumsden).

Data Handling: The areas of urban centres were multiplied by 0.35, a conservative estimate of imperviousness within these urban centres. (Perkins 2004).

Data Quality/Caveats: This land classification is not equivalent to impervious area, but it is correlated and provides the best estimate from available data sources.

Discussion: Urban municipalities should be required to prepare stormwater management plans to address the water quality impacts of stormwater. Stormwater management plans that incorporate Beneficial/Best Management Practices should be considered as a response indicator.

Municipal Wastewater Effluent Discharge Indicator

What is this indicator, and why is it important?

This indicator reports on the percentage of the annual municipal wastewater effluent discharge loading from an urban wastewater treatment plant to the background concentration of nutrients in the system. Municipal wastewater effluent discharge is one of the largest origins of point-source pollution, by volume, to surface water in Canada (Environment Canada 2004).

Effluent may contain high concentrations of nitrogen and phosphorus, which can lead to eutrophication in receiving waterbodies. Smaller waterbodies with low flow are more likely to have increased risk of eutrophication as there is lower dilution and dispersion in these systems.

There were 617 regulated wastewater works in Saskatchewan in 2002 (Saskatchewan Environment 2004). These are listed in Saskatchewan Environment regulatory records under the Environmental Management and Protection Act (2002) within the Water Regulations, 2002.

The level of wastewater treatment determines the type and concentration of pollutants in the effluent discharged.

Measure:

$$\text{Total Annual Nutrient Loading from Municipal Wastewater Discharge} = \text{Average concentration of nutrient (g/m}^3\text{) x Volume discharged (dam}^3\text{/year)}$$

$$\text{Nutrient Load from Municipal Wastewater as a Percentage of the Upstream Nutrient Load} = \frac{\text{Total annual nutrient loading from municipal wastewater discharge (kg/year)}}{\text{Upstream nutrient load (kg/year)}} \text{ x } 100$$

Data:

Table 10. Total annual phosphorus and ammonia-N loading from the City of Yorkton.

Year	Average annual phosphorus concentration (g/m³)	Average annual ammonia-N concentration (g/m³)	Total annual volume of wastewater discharged (dam³/year)	Total annual phosphorus loading (Kg P/year)	Total annual ammonia-N loading (Kg N/year)
2001	5.12	18.30	2,468	12,608	45,793
2002	4.95	14.51	2,321	12,211	32,781
Average	**5.03**	**16.41**	**2,394.5**	**12,409**	**39,287**

Table 11. Total annual upstream loading of phosphorus and ammonia-N.

Year	Total annual upstream phosphorus loading (Kg P/year)	Total annual upstream ammonia-N loading (Kg N/year)	Phosphorus load from municipal wastewater as a percentage of the upstream nutrient load	Ammonia-N load from municipal wastewater as a percentage of the upstream nutrient load
2001	4,584	2,572	275%	1,781%
2002	500	236	2,440%	13,919%
Average	**2,542**	**1,404**	**1,358%**	**7,850%**

Data Source: The concentrations of phosphorus and ammonia-N are from Saskatchewan Environment's Esquadat database. Volume of wastewater discharged is from the City of Yorkton's H.M. Bailey Water Pollution Control Plant. Flow data was obtained from Water Survey of Canada (http://www.wsc.ec.gc.ca/). Hydrometric flow data for the City of Yorkton is from the Water Survey of Canada (2005), Station ID: 05MB001 (Yorkton Creek near Ebenezer).

Discussion: The wastewater nutrient loading example provided for the City of Yorkton is somewhat unique because the city's wastewater treatment plant discharges into a relatively small stream that has little to no natural flow during the winter. Because the wastewater treatment plant has a relatively consistent outflow, this results in high nutrient loading when compared to the small receiving stream. On an average annual basis the nutrient load from the City of Yorkton's wastewater treatment plant is greater than the natural nutrient load. This means that the total phosphorus and total ammonia from the city exceeds the natural load by more than 100%. In other cities, such as Saskatoon, effluent is discharged into a large river with naturally high flow – thus the relative loading from the city is small compared to Yorkton.

Livestock Operations Indicator

What is this indicator, and why is it important?

This indicator is an expression of the risk that livestock operations pose to source water. Risk arises from two principal factors: the drainage characteristics of the sub-basin and regional livestock production patterns.

Livestock operations are a potential point source of nutrients (nitrogen and phosphorus), microorganisms (e.g. bacteria, fecal coliforms, *Cryptosporidium, Giardia*) and organic material such as livestock wastes, through runoff, soil water and groundwater movement.

Measure: If we assume that livestock operations have an equal chance of being distributed throughout a watershed and that the chance of being located near a watercourse increases with the length of streamcourse in a watershed then we can predict the number of livestock operations that are located within 300 m of a streamcourse (triggering the *Ag Ops Act*). The measure is an inherent risk factor of the watershed, dealing with drainage characteristics. This is a conservative assumption; in reality, livestock operations have a tendency to be located closer to streamcourses.

$$\text{Livestock Operations Within 300 m of Streamcourse} = \frac{\text{Watershed area within 300 m of streamcourse (ha)}}{\text{Total watershed area (ha)}} \times \text{Number of livestock operations}$$

Rating Scheme:

Intensive Livestock Operations
Low Stress - Estimated number of livestock operations within 300 m of a waterbody is less than 18.
Moderate Stress – Estimated number of livestock operations within 300 m of a waterbody is between 18 and 35.
High Stress – Estimated number of livestock operations within 300 m of a waterbody is more than 35.

Data:

Table 12. Livestock operations within 300 m buffer of Lower Souris Sub-basins.

Sub-basin	Sub-basin area (ha)	Percentage of sub-basin in 300 m buffer	Number of livestock operations	Estimated number of livestock operations within 300 m of a waterbody
Antler River	307,708	17	207	35
Four Creeks	190,960	13	119	16
Long Creek	230,756	17	100	17
Moose Mountain Creek	608,868	21	230	49
Pipestone Creek	389,805	24	220	54

Data Source: Number of livestock operations is from the 2001 Census of Agriculture (Statistics Canada 2002a).

Data Discussion: This indicator could be calculated using data from other agricultural censuses on a five-year basis to derive temporal trends.

Discussion: The estimated number of livestock operations within 300 m of a waterbody within Moose Mountain Creek and Pipestone Creek Sub-basins are placing a High stress on these sub-basins relative to the other sub-basins.

Agricultural Non-Point Sources

Agricultural activities are widespread and have intensified over time throughout the southern prairies. Cropping practices, livestock grazing, manure application and agricultural inputs can all contribute to non-point source pollution.

An appropriate indicator for assessing non-point source pollution is a general non-point source pollution model. Until such a model is developed, four substitute metrics can be used: Soil Erosion, Fertilizer Inputs, Pesticide Inputs, and Manure Application.

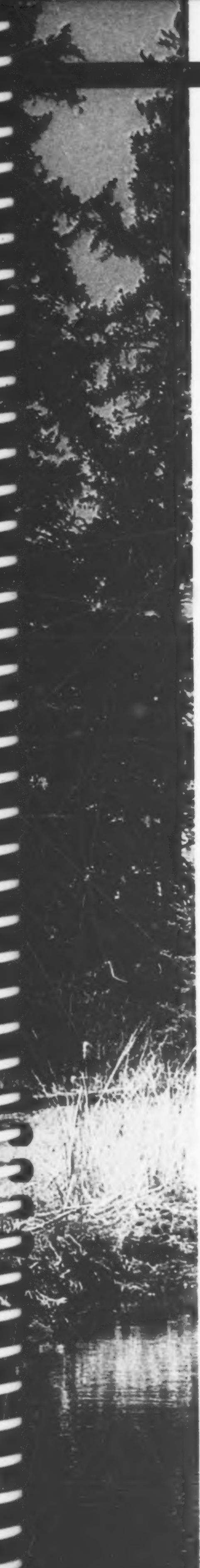
Discussion: At this point multiple indicators are recommended for capturing the wide range of impacts that agricultural land management practices have on water quality. Ultimately these should be incorporated into a non-point source model.

Soil Erosion Indicator

What is this indicator, and why is it important?

This indicator predicts the potential soil erosion from agricultural land caused by wind, precipitation, and surface runoff. Soil erosion is one of the primary causes of agricultural non-point source pollution, and is an important mechanism by which surface water may be impacted by agricultural land management.

Sediment deposition caused by soil erosion can affect surface water quality both physically and chemically. Some of the physical and chemical impacts of soil erosion to surface water include increased turbidity and increased loading of nutrients, especially nitrogen and phosphorus.



Measure: Three models can be used to calculate soil loss: the Revised Universal Soil Loss Equation (RUSLE); the Wind Erosion Equation (WEQ); and the Tillage Erosion Prediction Simulation (TEPS) models.

The RUSLE is a soil erosion model that predicts long-term average potential soil loss caused by rainfall and runoff.

RUSLE: $A = R \times K \times L \times S \times C \times P$ *(Wischmeier and Smith 1978)*

Where:

A	Estimated erosion in tons per acre per year
R	Rainfall erosivity factor (the amount and intensity of rainfall an area receives)
K	Soil erodibility factor (calculated using several physical soil properties: texture, organic matter, infiltration rate and structure)
L	Slope length factor
S	Slope steepness factor
C	Cover and management factor
P	Support practice factor (practices used for erosion control)

The WEQ is a model that predicts soil loss caused by wind.

WEQ: $E = f(I, K, C, L, V)$

Where:

E	Estmated erosion in tons per acre per year
f	Function of ( )
I	Erodibility factor (e.g. texture and aggregation)
K	Surface roughness factor (e.g. ridges)
C	Climate factor
L	Unsheltered length of field factor (how open the field is)
V	Vegetative cover factor (cover type, density, etc.)

Soil erosion classes were developed for crop productivity purposes, not water quality concerns. The criteria for defining the tolerance limits for the purpose of preventing or reducing damage to offsite water quality may be distinct from those tolerances designed to preserve cropland productivity (Renard et al. 1997).

Rating Scheme:
The rating system from Wall et al. (2002) has been revised to conform to the categories utilized for the stress indicators in this document.

Soil Erosion
Low Stress - Soil erosion is less than 11 tonnes/hectare/year.
Moderate Stress – Soil erosion is between 11 and 22 tonnes/hectare/year.
High Stress – Soil erosion is greater than 22 tonnes/hectare/year.

Data:

Table 13. Estimated hectares and percentage of cultivated land in the Lower Souris River Watershed susceptible to wind and water erosion in 2005.

	Low risk	Moderate risk	High risk
Wind erosion risk	732,890 ha (93%)	31,015 ha (4%)	13,484 ha (2%)
Water erosion risk	679,926 ha (86%)	90,473 ha (11%)	6,990 ha (1%)

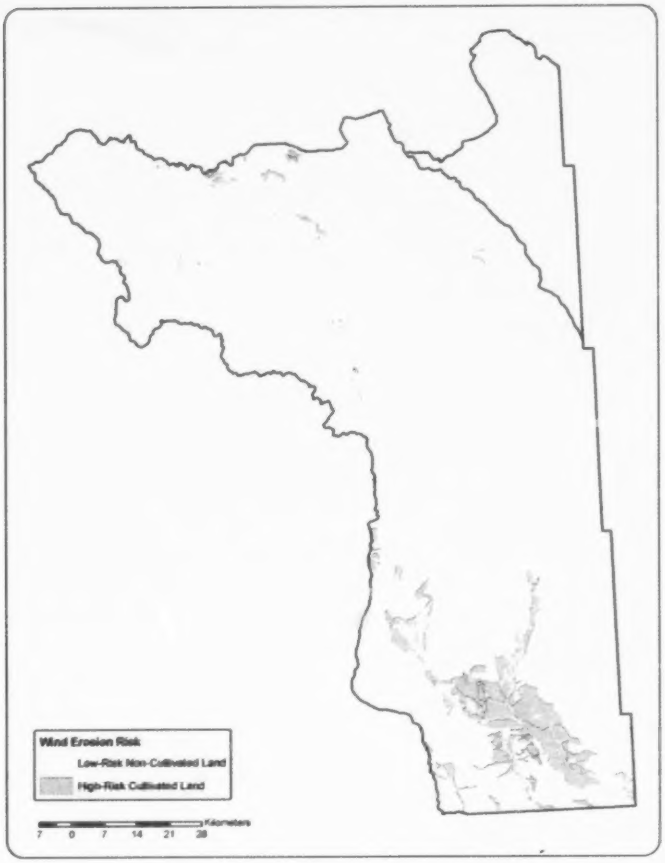


Figure 12. Distribution of soils in the Lower Souris River Watershed which have a wind erosion risk factor of Low and High.

Data Source: The cover data is from the Southern Digital Land Cover (1994).

Data Handling: Soil loss estimates are at a 1:100,000 scale, utilizing Soil Landscape of Canada (SLC) polygons.

Data Discussion: Prairie Farm Rehabilitation Administration (PFRA) is developing province-wide soil loss estimates that will combine wind, water, and tillage erosion. The results will be a qualitative evaluation on soil erosion and soil quality. It will not be reporting on erosion risk in the five soil erosion classes (tolerable, low, moderate, high, and severe). The new PFRA erosion measures will be a valuable product for the Saskatchewan Watershed Authority and the State of the Watershed Reporting. This new erosion measure will better reflect management practices and incorporate the new Saskatchewan Land Resource Centre-Agriculture and Agri-Food Canada's Saskatchewan Soil Resource Database and include Census of Agriculture data from between 1981 and 2001. Temporal analysis can take place on a five-year basis as determined by the Agriculture Census.

Discussion: Soil erosion in the Lower Souris Watershed is quite low. Risk of soil erosion caused by wind is low, with only 6% of cultivated soils in the watershed in the Moderate to High risk categories. Cultivated soils in the Lower Souris River Watershed are also at low risk for water erosion, with only 11% and 1% in the Moderate and High risk classes, respectively. Conservation measures such as zero tillage, contour cropping, sod-based rotations, or permanent cover are some methods that can be utilized to reduce the erosion potential of soils (Wall et al. 2002).

Fertilizer Inputs Indicator

What is this indicator, and why is it important?

This indicator measures the intensity of fertilizer use by watershed between 1986 and 2001. Agricultural application of fertilizer can be a major source of nutrients to a waterbody.

Fertilizers maintain and improve nutrient availability of soils for crop growth. Runoff of fertilizers can increase nutrient loading, which can affect the water quality of receiving waterbodies.

Measure:

$$\text{Fertilizer Input Intensity} = \frac{\text{Fertilizer input cost (\$)}}{\text{Total watershed area (ha)}}$$

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Fertilizer Input Intensity

Low Stress - Fertilizer use is less than $5.99/hectare.

Moderate Stress – Fertilizer use is between $5.99 and $21.09/hectare.

High Stress – Fertilizer use is greater than $21.09/hectare.

Data:

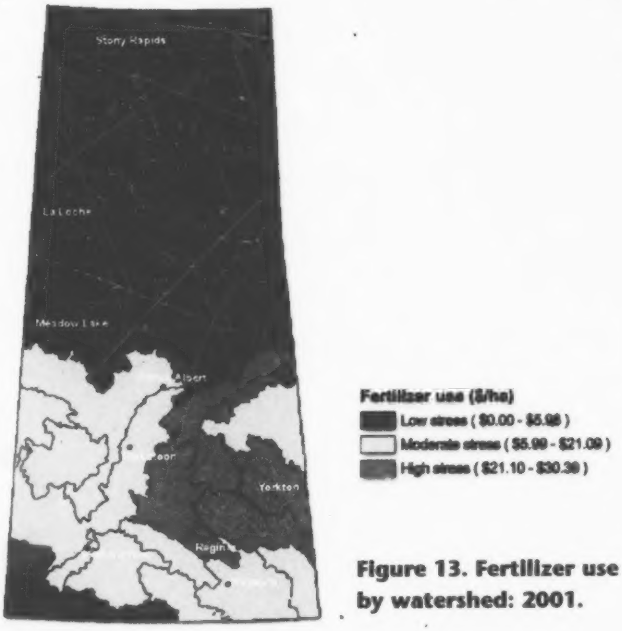
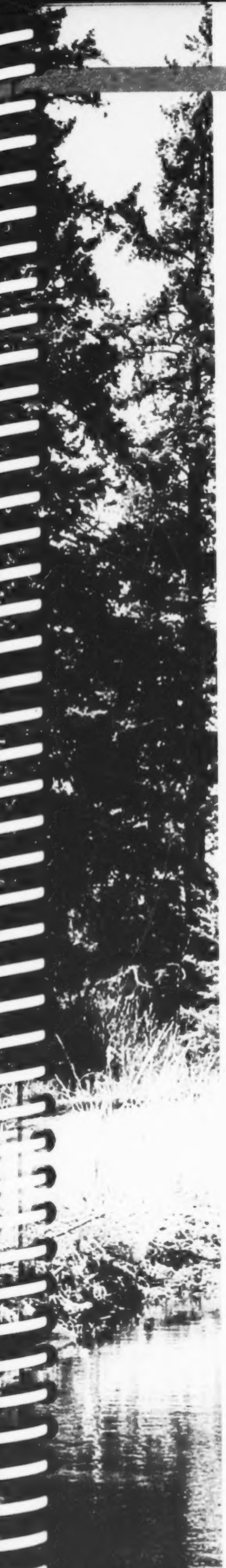

Stony Rapids
La Loche
Meadow Lake
Albert
oon
Yorkton
Regin
Fertilizer use ($/ha)
Low stress ($0.00 - $5.98)
Moderate stress ($5.99 - $21.09)
High stress ($21.10 - $30.39)

Figure 13. Fertilizer use by watershed: 2001.



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Measure:

$$\text{Fertilizer Input Intensity} = \frac{\text{Fertilizer input cost (\$)}}{\text{Total watershed area (ha)}}$$

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Fertilizer Input Intensity

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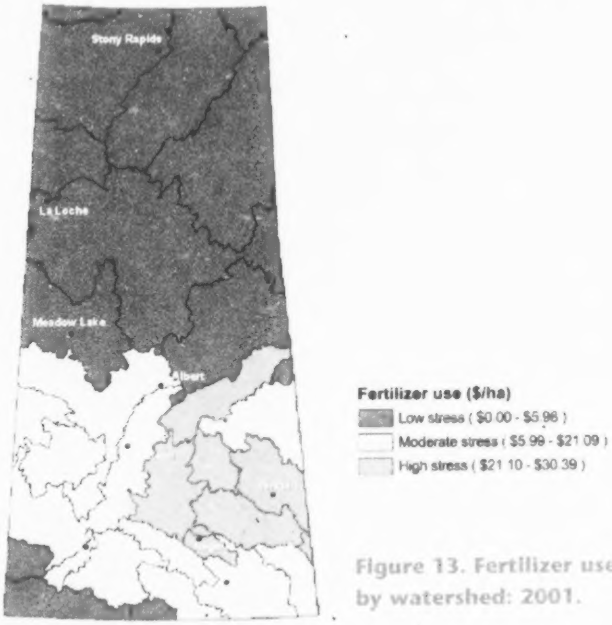
Moderate Stress – Fertilizer use is between $5.99 and $21.09/hectare.

High Stress – Fertilizer use is greater than $21.09/hectare.

Data:


Stony Rapids
La Loche
Meadow Lake
Albert
Fertilizer use ($/ha)
Low stress ($0.00 - $5.98)
Moderate stress ($5.99 - $21.09)
High stress ($21.10 - $30.39)

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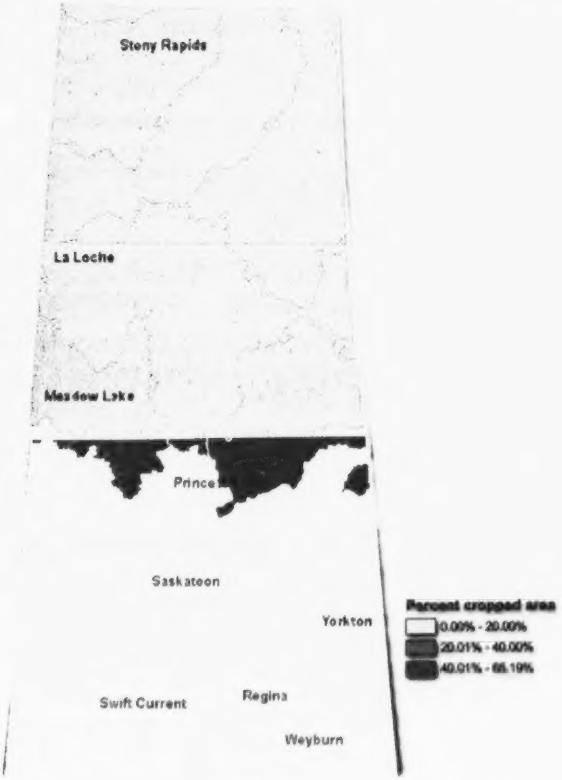

Figure 14. Percent cropped area by watershed: 2001.

Data Source: Fertilizer use data for this indicator was obtained from Census of Agriculture for the 2001 Census years (Statistics Canada 2002a).

Data Quality/Caveats: By dividing the fertilizer use in the watershed by the total watershed area, instead of the cropped area within the watershed, the measure assesses the health of the watershed not just the health of the cropped areas. It should be noted that there are watersheds with a small percentage of cropped area and high input costs for these cropped areas. In these circumstances there is potential for increased risks to local waterways.

Data Discussion: This measure permits temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact fertilizers have on the health of watersheds. To further assess the potential impact of chemical application on watersheds an estimate of the mass of chemical loadings per watershed is needed. Using information on the amount of fertilizer added and the amount of fertilizer removed during cropping we could estimate the potential amount of excess fertilizer that has been added. Using this information a leaching potential and the runoff potential of nitrogen and phosphorus could be determined.

In the Draft Agri-Environmental Indicators Report 2005 (De Jong et al. 2005) an Indicator to assess the Risk of Water Contamination by Nitrogen (IROWC-N) was developed for all of Canada at a provincial scale. IROWC-N looked at the risk of surface water bodies contaminated by nitrogen moving from agricultural areas treated with fertilizers and manure. It should be noted that IROWC-N has several limitations, as the calculation of this indicator has many assumptions and approximations and the results are estimates of the risk of water contamination by nitrogen. Despite these limitations the IROWC-N does identify areas in Saskatchewan that are at risk for nitrogen losses to surface water bodies.

Discussion: In 2001, relative to all watersheds in Saskatchewan, the fertilizer use in the Assiniboine River, Carrot River, Lower Qu'Appelle River, Upper Qu'Appelle River, Quill Lakes, and Wascana Creek Watersheds had a high stress potential. All of the watersheds with moderate and high stress potential have greater than 40% cropped area, with the exception of the Lake Winnipegosis Watershed which had 29% cropped area.

Pesticide Inputs Indicator

What is this indicator, and why is it important?
This indicator measures the intensity of pesticide use by watershed between 1986 and 2001. Agricultural application of pesticides can be a major source of chemicals to a water body.

Pesticides are used to reduce pest species, such as weeds, insects, fungi, and parasites. Pesticides can have toxic effects on aquatic species.

Measure:

$$\text{Pesticide Input Intensity} = \frac{\text{Pesticide input cost (\$)}}{\text{Total watershed area (ha)}}$$

Rating Scheme:
Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Pesticide Input Intensity
Low Stress - Pesticide use is less than $6.65/hectare.
Moderate Stress – Pesticide use is between $6.65 and $17.65/hectare.
High Stress – Pesticide use is greater than $17.65/hectare.

Data:

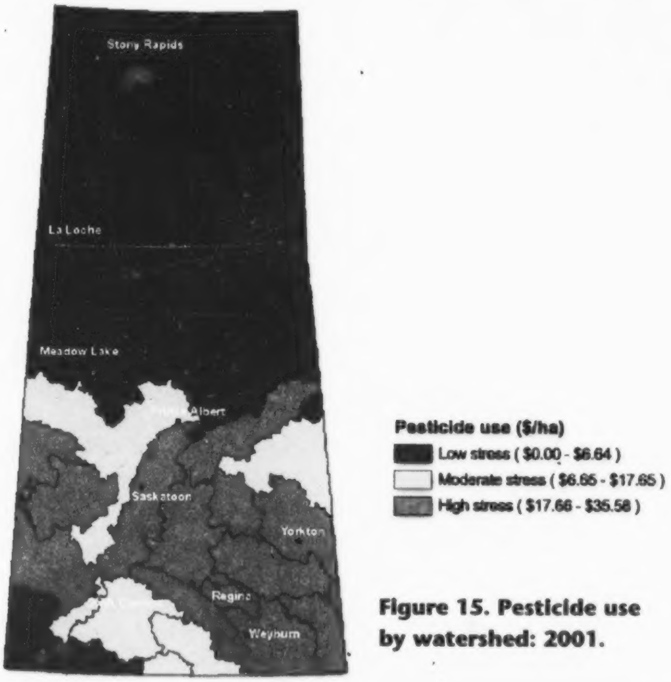
Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Weyburn
Pesticide use ($/ha)
Low stress ($0.00 - $6.64)
Moderate stress ($6.65 - $17.65)
High stress ($17.66 - $35.58)

Figure 15. Pesticide use by watershed: 2001.

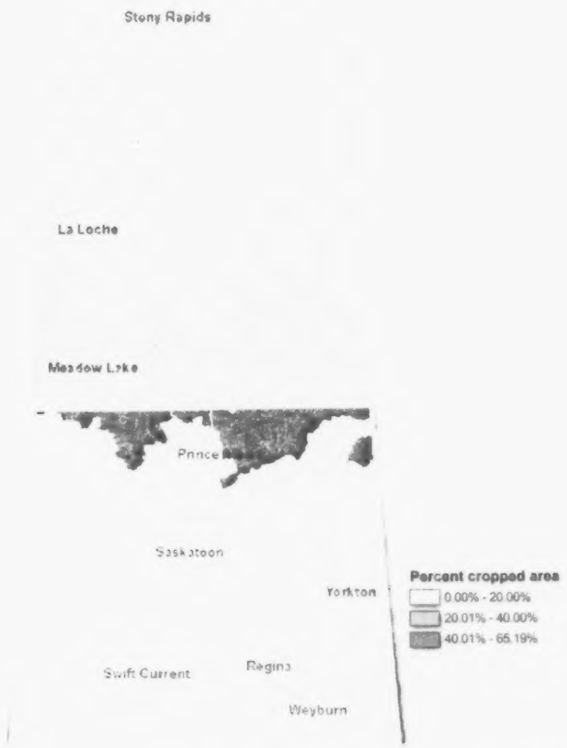

Figure 14. Percent cropped area by watershed: 2001.

Data Source: Fertilizer use data for this indicator was obtained from Census of Agriculture for the 2001 Census years (Statistics Canada 2002a).

Data Quality/Caveats: By dividing the fertilizer use in the watershed by the total watershed area, instead of the cropped area within the watershed, the measure assesses the health of the watershed not just the health of the cropped areas. It should be noted that there are watersheds with a small percentage of cropped area and high input costs for these cropped areas. In these circumstances there is potential for increased risks to local waterways.

Data Discussion: This measure permits temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact fertilizers have on the health of watersheds. To further assess the potential impact of chemical application on watersheds an estimate of the mass of chemical loadings per watershed is needed. Using information on the amount of fertilizer added and the amount of fertilizer removed during cropping we could estimate the potential amount of excess fertilizer that has been added. Using this information a leaching potential and the runoff potential of nitrogen and phosphorus could be determined.

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Discussion: In 2001, relative to all watersheds in Saskatchewan, the fertilizer use in the Assiniboine River, Carrot River, Lower Qu'Appelle River, Upper Qu'Appelle River, Quill Lakes, and Wascana Creek Watersheds had a high stress potential. All of the watersheds with moderate and high stress potential have greater than 40% cropped area, with the exception of the Lake Winnipegosis Watershed which had 29% cropped area.

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What is this indicator, and why is it important?

This indicator measures the intensity of pesticide use by watershed between 1986 and 2001. Agricultural application of pesticides can be a major source of chemicals to a water body.

Pesticides are used to reduce pest species, such as weeds, insects, fungi, and parasites. Pesticides can have toxic effects on aquatic species.

Measure:

$$\text{Pesticide Input Intensity} = \frac{\text{Pesticide input cost (\$)}}{\text{Total watershed area (ha)}}$$

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Pesticide Input Intensity
Low Stress - Pesticide use is less than $6.65/hectare.
Moderate Stress – Pesticide use is between $6.65 and $17.65/hectare.
High Stress – Pesticide use is greater than $17.65/hectare.

Data:

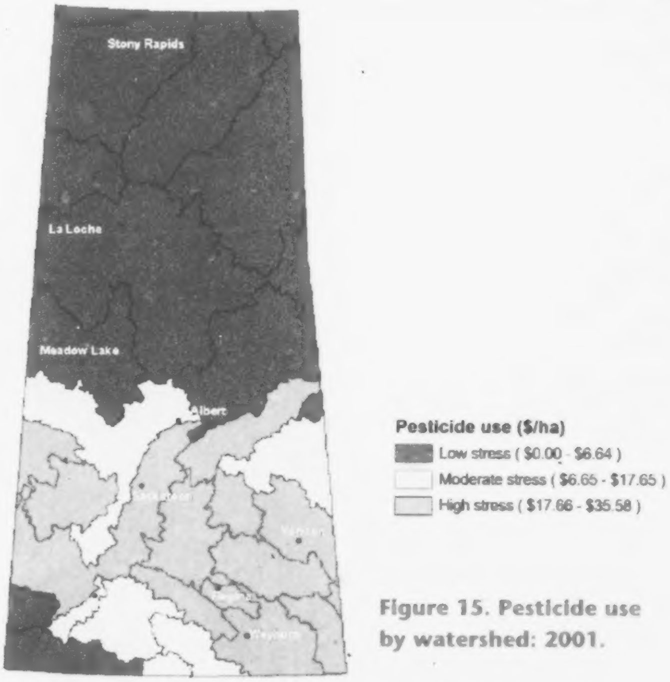
Stony Rapids
La Loche
Meadow Lake
Albert
Pesticide use ($/ha)
Low stress ($0.00 - $6.64)
Moderate stress ($6.65 - $17.65)
High stress ($17.66 - $35.58)

Figure 15. Pesticide use by watershed: 2001.

Data Source: Pesticide use data for this indicator was obtained from Census of Agriculture for the 2001Census year (Statistics Canada 2002a).

Data Quality/Caveats: By dividing the pesticide use in the watershed by the total watershed area, instead of the cropped area within the watershed, the measure assesses the health of the watershed not just the health of the cropped areas. It should be noted that there are watersheds with a small percentage of cropped area and high input costs for these cropped areas. In these circumstances there is potential for increased risks to local waterways.

In order to protect the privacy of individual farms the Agriculture Census does not provide data in Rural Municipalities with less than two farms reporting. It is assumed that the resulting missing data due to this privacy policy is negligible.

Data Discussion: This measure permits temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact fertilizers and pesticides have on the health of watersheds. To further assess the potential impact of chemical application on watersheds an estimate of the mass of chemical loadings per watershed is needed. Likely this is not possible to calculate for pesticides with the current data.

Discussion: In 2001, relative to all watersheds in Saskatchewan pesticide use in the Assiniboine River, Battle River, Carrot River, Eagle Creek, Lower Qu'Appelle River, Upper Qu'Appelle River, Lower Souris River, Upper Souris River, Moose Jaw River, South Saskatchewan River, Quill Lakes and Wascana Creek Watersheds had a high stress potential. All of the watersheds with moderate and high stress potential have greater than 40% cropped area, with the exception of the Lake Winnipegosis Watershed which had 29% cropped area.

Manure Application Indicator

What is this indicator, and why is it important?
This indicator reports on the percent of the watershed where manure has been applied. Manure is typically applied to the land at the level of nitrogen required, which may result in other nutrients, including phosphorus, being applied in excess of crop requirements. Therefore, if the manure is applied at an appropriate rate for nitrogen the application will increase the potential for ground and surface water contamination by phosphorus. Ground and surface water quality can be affected in two ways: through leaching to groundwater and runoff to surface waters.

Measure:

$$\text{Manure Application} = \frac{\text{Area of manure application in a watershed (ha)}}{\text{Total watershed area (ha)}} \times 100$$

Rating Scheme:
Insufficient data from appropriate scientific studies existed to rate this indicator.

Data:

Table 14. Manure application in the Souris River Basin by sub-basin for 2001.

Sub-basin	Hectares of manure application	Manure application indicator value
Antler River	4,167	1.35 %
Four Creeks	2,161	1.13 %
Long Creek	1,666	0.72 %
Moose Mountain Creek	5,058	0.83 %
Pipestone Creek	4,249	1.09 %
Souris River	7,256	0.63 %

Data Source: Manure application data was obtained from 2001 Census of Agriculture (Statistics Canada 2002a).

Data Quality/Caveats: This indicator does not take into account the type of animal manure, or the method, timing, or location of manure application. All of these factors have the potential to influence the risk of surface water and groundwater contamination.

Data Discussion: Censuses of other years (every five years) can be used for illustrating temporal trends.

Discussion: This indicator suggests that manure application is relatively evenly distributed throughout the Souris River Basin.

To further assess the potential impact of manure application on watersheds an estimate of the potential risk of nitrogen loading to surface water bodies should also be considered. Please see the IROWC-N section of the Chemical Inputs indicator for further information on nitrogen loading.

Oil and Gas

The extraction, refinement, and transportation of oil and gas within Saskatchewan are important components of our economy, contributing approximately $2 billion in 2003 (CAPP 2003). All three sectors are environmentally regulated by the *Provincial Oil and Gas Regulations* to ensure proper reclamation of environments impacted by the oil and gas industry.

Oil and gas exploration and development has the potential to impact watershed health in a number of ways, including: oil spills; wastewater disposal; leaching of surface discharge; stormwater runoff from well sites; surface water and groundwater extraction activities; leaking of transport pipelines and underground storage; and impairment of freshwater aquatic life caused by the aforementioned activities (Confluence Consulting Inc. 2004).

Provincially, the oil and gas regulations ensure that operations incorporate multiple built-in containment and protection systems to ensure there is little or no impact to the air, land and water. Though spills and gas leaks are rare events, it is important to have indicators that measure the potential risk of these activities.

Oil and Gas Spill Indicator

What is this indicator, and why is it important?
This indicator reports on the number and volume of upstream oil and gas spills by watershed. Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates.

Although less than 1% of the total water consumed in Saskatchewan is utilized by upstream petroleum operations (which includes all activities that find, produce, and process oil and natural gas) (Saskatchewan Environment 2003), there still remains the potential for groundwater contamination. Incidents such as gas migration and casing leaks pose contamination threats to groundwater, a threat that increases with the number of wells drilled per unit area.

Measure:

$$\text{Number of Oil and Gas Spills per Square Kilometre} = \frac{\text{Number of oil and gas spills between 1993 and 2003}}{\text{Total watershed area (km}^2\text{)}}$$

$$\text{Average Annual Volume of Oil and Emulsion Spills per Square Kilometre} = \frac{\text{Average annual volume of oil and emulsion spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$$

$$\text{Average Annual Volume of Saltwater Spills per Square Kilometre} = \frac{\text{Average annual volume of saltwater spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$$

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Number of Oil and Gas Spills per Square Kilometre

Low Stress - The number of oil and gas spills is less than 0.006381 spills/km^2.

Moderate stress – The number of oil and gas spills is between 0.006381 and 0.038390 spills/km^2.

High stress – The number of oil and gas spills is greater than 0.038390 spills/km^2.

Average Annual Volume of Oil and Emulsion Spills per Square Kilometre

Low Stress - The average annual volume of oil and emulsion spills is less than 9 litres/km^2.

Moderate stress – The average annual volume of oil and emulsion spills is between 9 and 46 litres/km^2.

High stress – The number of oil and gas spills is greater than 46 litres/km^2.

Average Annual Volume of Saltwater Spills per Square Kilometre

Low Stress - The average annual volume of saltwater spills is less than 13 litres/km^2.

Moderate stress – The average annual volume of saltwater spills is between 13 and 100 litres/km^2.

High stress – The number of saltwater spills is greater than 100 litres/km^2.

Data:

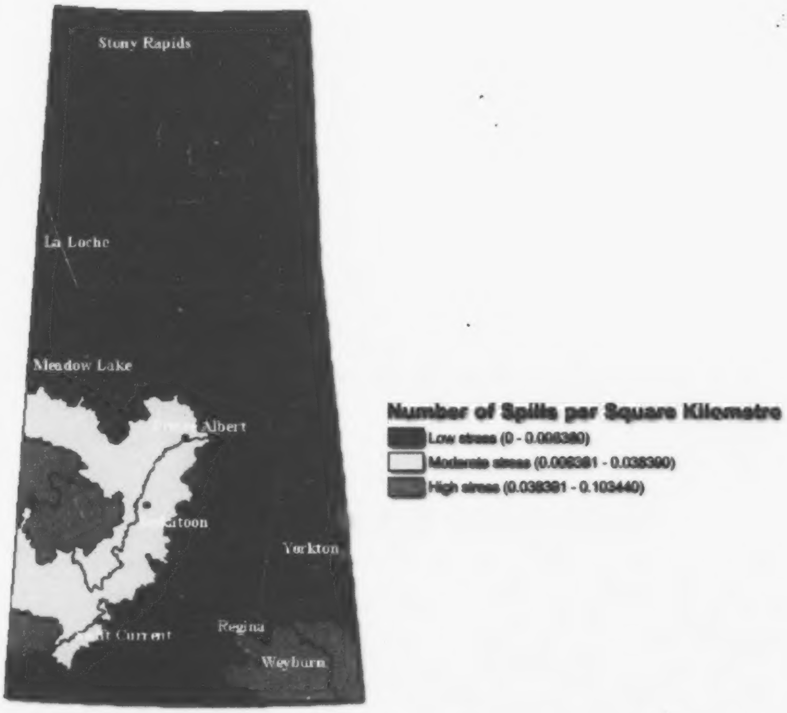
Stony Rapids
La Loche
Meadow Lake
Prince Albert
atoon
Yorkton
ift Current
Regina
Weyburn
Number of Spills per Square Kilometre
Low stress (0 - 0.006380)
Moderate stress (0.006381 - 0.038390)
High stress (0.038391 - 0.103440)

Figure 16. Number of oil and gas spills per square kilometre between 1993 and 2003, by watershed.

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Number of Oil and Gas Spills per Square Kilometre

Low Stress - The number of oil and gas spills is less than 0.006381 spills/km^2.

Moderate stress – The number of oil and gas spills is between 0.006381 and 0.038390 spills/km^2.

High stress – The number of oil and gas spills is greater than 0.038390 spills/km^2.

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High stress – The number of oil and gas spills is greater than 46 litres/km^2.

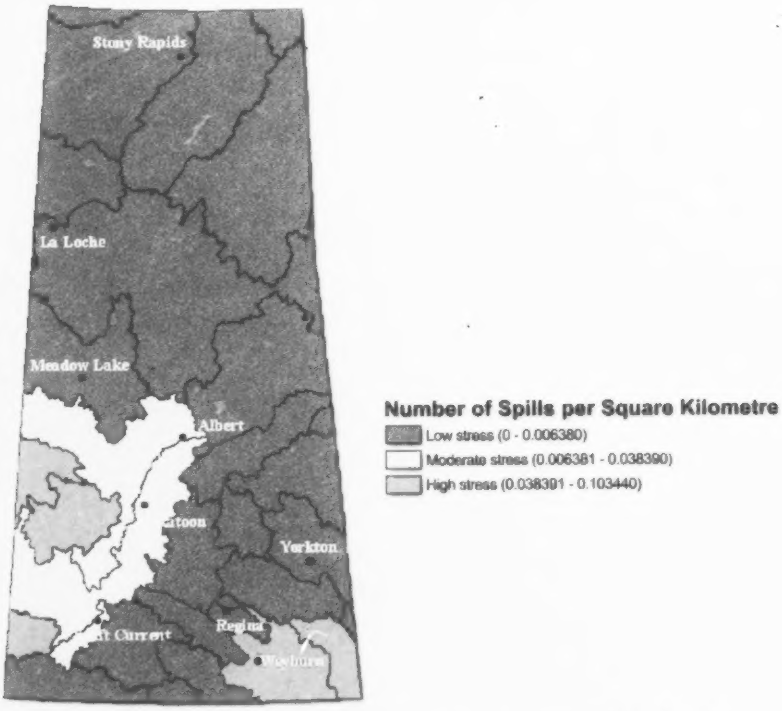
Average Annual Volume of Saltwater Spills per Square Kilometre

Low Stress - The average annual volume of saltwater spills is less than 13 litres/km^2.

Moderate stress – The average annual volume of saltwater spills is between 13 and 100 litres/km^2.

High stress – The number of saltwater spills is greater than 100 litres/km^2.

Data:


Stony Rapids
La Loche
Meadow Lake
Albert
atoon
Yorkton
t Current
Regina
Weyburn
Number of Spills per Square Kilometre
Low stress (0 - 0.006380)
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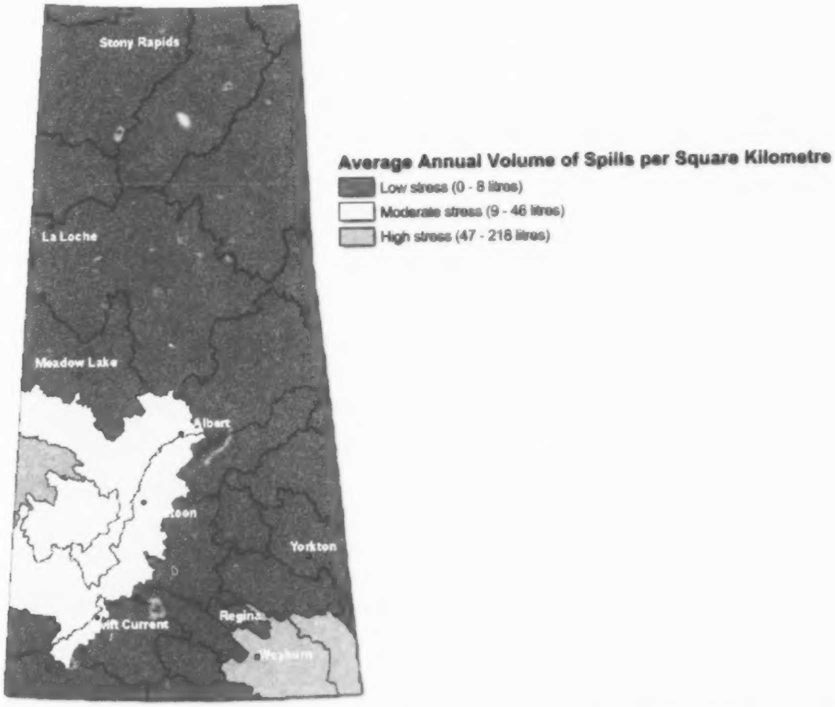

Stony Rapids
La Loche
Meadow Lake
Albert
toon
Yorkton
wift Current
Regina
Weyburn
Average Annual Volume of Spills per Square Kilometre
Low stress (0 - 8 litres)
Moderate stress (9 - 46 litres)
High stress (47 - 218 litres)

Figure 17. Average annual volume of oil and emulsion spills per square kilometre between 1993 and 2003, by watershed.

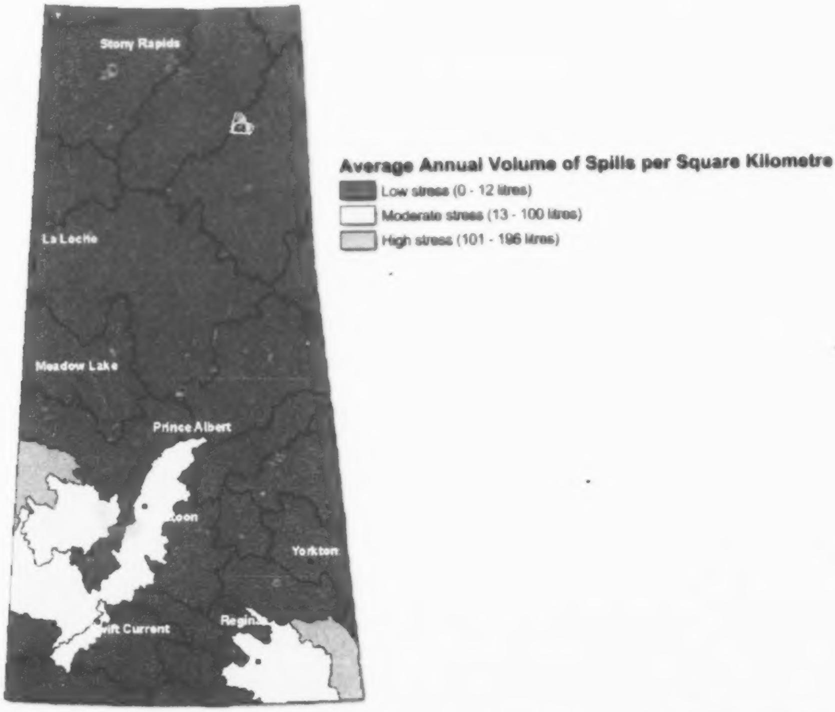
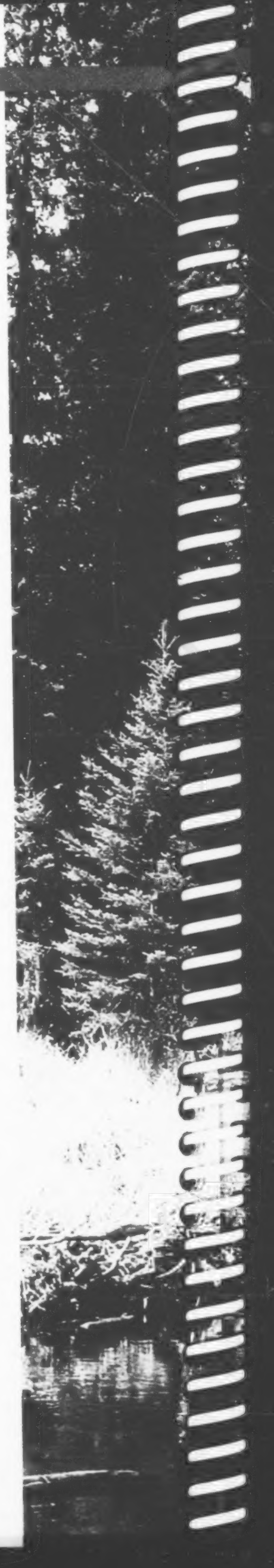

Stony Rapids
La Loche
Meadow Lake
Prince Albert
toon
Yorkton
wift Current
Regina
Average Annual Volume of Spills per Square Kilometre
Low stress (0 - 12 litres)
Moderate stress (13 - 100 litres)
High stress (101 - 196 litres)

Figure 18. Average annual volume of saltwater spills per square kilometre between 1993 and 2003, by watershed.



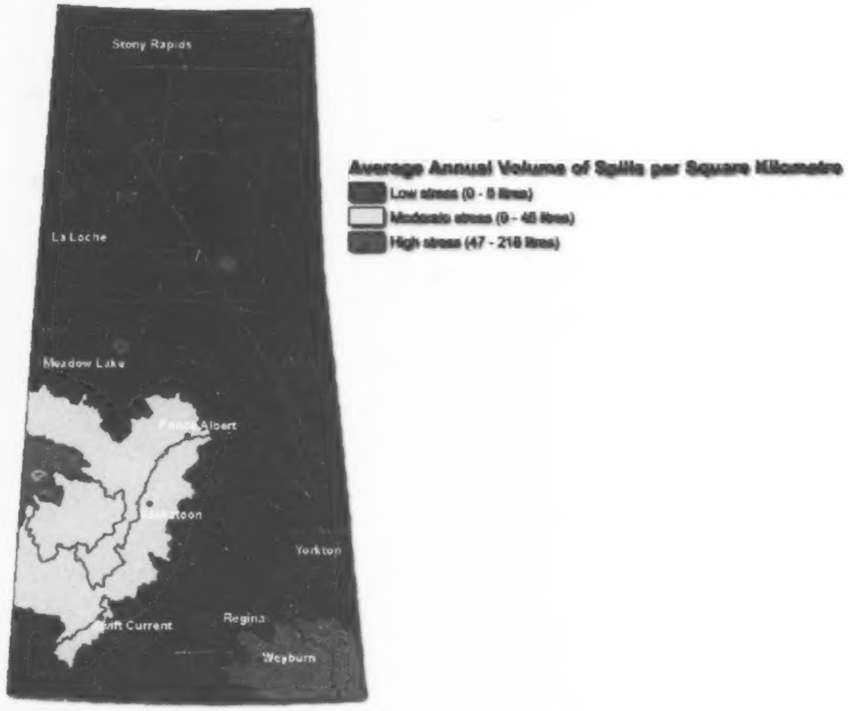

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Average Annual Volume of Spills per Square Kilometre
Low stress (0 - 8 litres)
Moderate stress (9 - 46 litres)
High stress (47 - 218 litres)

Figure 17. Average annual volume of oil and emulsion spills per square kilometre between 1993 and 2003, by watershed.

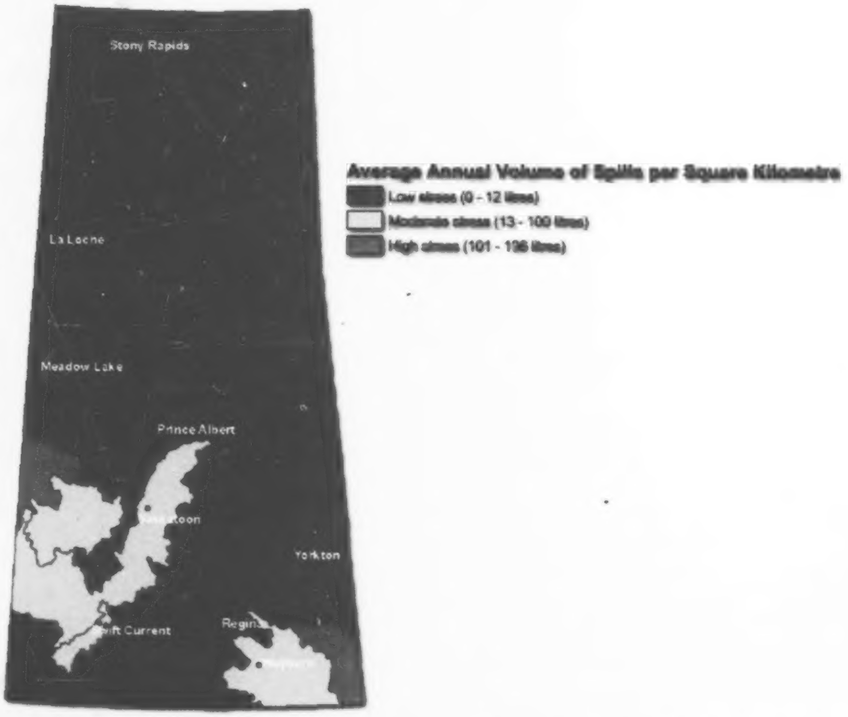

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Average Annual Volume of Spills per Square Kilometre
Low stress (0 - 12 litres)
Moderate stress (13 - 100 litres)
High stress (101 - 196 litres)

Figure 18. Average annual volume of saltwater spills per square kilometre between 1993 and 2003, by watershed.

Data Source: The number and volume of oil and gas spills in Saskatchewan was obtained from Saskatchewan Industry and Resources' Upstream Oil and Gas Sites Spill Database.

Data Handling: Saskatchewan Industry and Resources' database contains information on oil and gas spills between 1991 and 2005. However, spill data for 2004 and 2005 is currently incomplete.

Data Quality/Caveats: The Oil and Gas Spill Indicator estimates the relative stress potential of an upstream oil and gas spill. Therefore, Figures 17 and 18 are based on the volume of oil spilled and they do not take into account the amount of materials recovered from the spill. The percentage of the volume recovered is on average 71% for oil and emulsion spills and 54% for saltwater spills.

Discussion: The number of oil and gas spills and the average annual volume of oil and gas spills per square kilometre are categorized as being of High stress potential in the Lower and Upper Souris River and Battle River Watersheds. The North Saskatchewan, South Saskatchewan, Eagle Creek, and Swift Current Watersheds are categorized as Moderate stress potential. All other watersheds have a Low stress potential. The total number of oil and gas wells in Saskatchewan will continue to increase in the foreseeable future. The rate of increase can be determined by observing the number of wells drilled each year. The volume of oil and gas spills by watershed is highly correlated with the number of oil and gas wells within the watershed ($r^2=0.73$, $p<0.001$). Therefore, as the number of oil and gas wells in Saskatchewan increases we can predict an increase in the number and volume of oil and gas spills.

Mining Indicator

What is this indicator, and why is it important?

This indicator will report on the number and type of mines within a watershed. Mines can affect watershed health through the release of air- and water-borne chemicals, by increasing water temperature, and by altering flow characteristics of rivers. Abandoned mines can also have an impact on water quality through acid mine drainage from tailings.

In Saskatchewan, the projected 2004 expenditures for the mining industry are expected to reach $53 million, a significant increase from 2003. Uranium, diamond and gold explorations are expected to increase while at the same time Saskatchewan remains the source of approximately one third of the world's potash. Other minerals mined in Saskatchewan include: copper, zinc, lead, nickel, salt, sodium sulphate, aggregate, bentonite and silica sand (Kelly et al. 2004).

Measure:

Number of Mines = Number of active and inactive mines per watershed

This measure does not include abandoned mines.

Data:

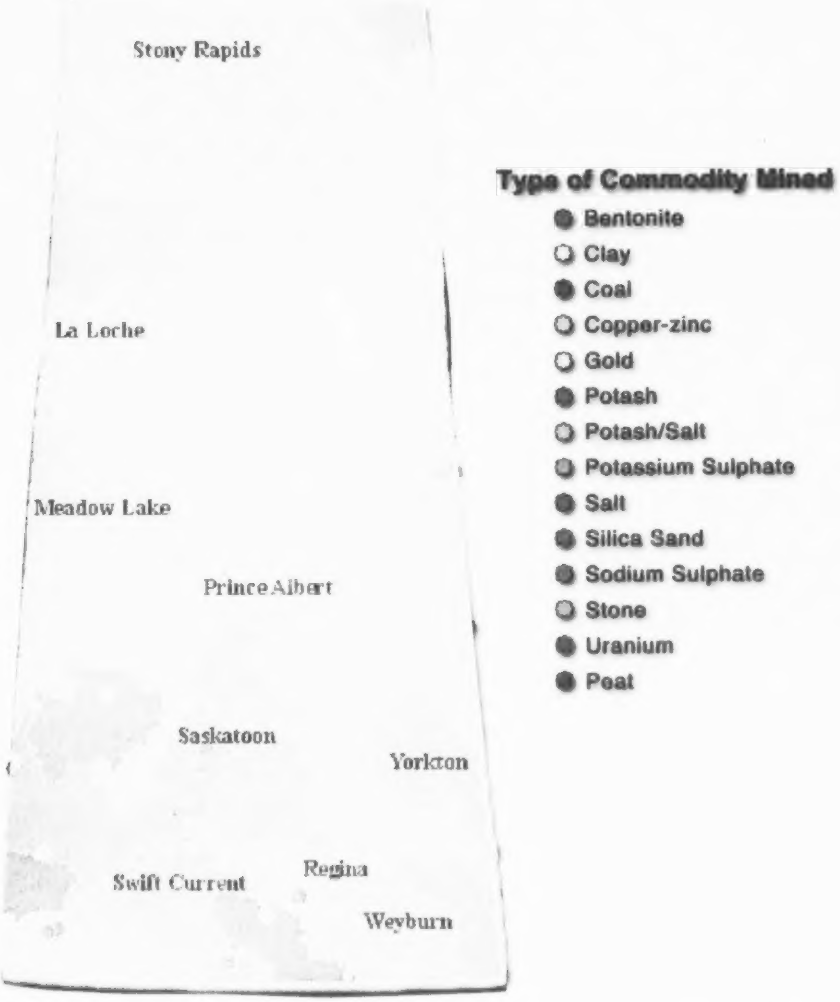

Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Swift Current
Regina
Weyburn
Type of Commodity Mined
Bentonite
Clay
Coal
Copper-zinc
Gold
Potash
Potash/Salt
Potassium Sulphate
Salt
Silica Sand
Sodium Sulphate
Stone
Uranium
Peat

Figure 19. Active and inactive mine locations by watershed: 2001.
Note: The abandoned mines in Saskatchewan are not included on this map.

Data Source: Data Source: The location of mines was obtained from the Geological Atlas of Saskatchewan (Saskatchewan Industry and Resources 2004).

Discussion: Depending on the type of mine there are different parameters of concern when trying to determine the stress they may have on a particular watershed. Additional information and details with regard to mine type and their potential impacts is available in the form of environmental impact assessments (EIAs), monitoring (biological/chemical) and modeling (Saskatchewan Environment and Saskatchewan Industry and Resources).

An additional component to be added to this indicator, once data is obtained, is the number of abandoned mines within a watershed.

Forestry Indicator

What is this indicator, and why is it important?
This indicator will look at the percent of forested area disturbed by human activities within a watershed. Human activities that cause disturbance within a forested area include harvesting and road construction. Potential effects of human disturbance on water quality and quantity include: increased sedimentation, increased nutrient and ion loading, introduction of toxic chemicals from harvesting activities and increased movement of organic debris; temperature changes; and streamflow increases or decreases.

Forestry is an important industry in northern Saskatchewan contributing $750 million to our economy. Approximately half of the province is forested, with 13.3 million hectares available for harvest (Saskatchewan Environment 1993). Forestry operations, on average, remove tress from over 24,000 hectares per year (Saskatchewan Environment 2003).

The potential impacts of deforestation include increased flows, increased flood peaks and flood volumes (Andreassian 2004), and increased erosion and sedimentation within the watershed. An investigation conducted by Pomeroy et al. (1997) on the hydrological processes in the southern boreal forest found that snowmelt occurs up to three times faster in clear-cuts compared to mature stands. Because of the faster snowmelt there was increased runoff from clear-cut areas resulting in less infiltration to groundwater.

Harvest practices designed to model natural fire patterns are now being implemented by the forestry companies in Saskatchewan. Saskatchewan Environment began enforcing these new harvest practices beginning in 2004 (Saskatchewan Environment 2003). Recently burned areas tend to have less of an impact with regard to increased nutrient yields and mercury translocation than logged areas (Richter and Ralston 1982; Garcia and Carignan 1999). These new methods of harvesting could help reduce the effects of clear cutting and improve the likelihood of regeneration.

Though the forestry indicator does not apply to southern watersheds in Saskatchewan, it is imperative to include this indicator in the northern watersheds and those on the fringe of the Boreal Plains ecozone.

Measure:

$$\text{Percent of Forested Area Disturbed in Last 20 Years} = \frac{\text{Human disturbed forested area (ha)}}{\text{Forested area within the watershed (ha)}} \times 100$$

Data:

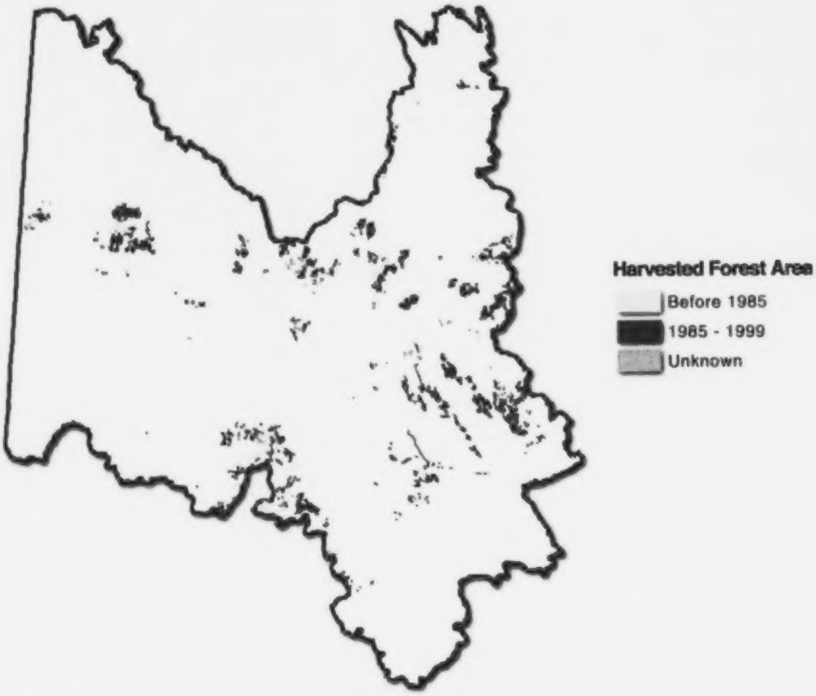


Figure 20. Map of the Beaver River Watershed showing the harvested forest area by year classes interpreted from the Forest Inventory Data.

Data Source: The disturbance type and year were obtained from Saskatchewan Environment and Resource Management, Forestry Branch's Forest Inventory Data.

Data Discussion: The intention of this indicator is to include and map all of the human disturbed forested areas by watershed. Currently, only the harvested (cutover) areas are included in Figure 20. Through the cooperation and collaboration of various organizations, we are currently in the process of obtaining data on additional types of human disturbances.

Discussion: Approximately 80% of the Beaver River Watershed is forested. Of the forested area 1.21% of it has been disturbed in the past 20 years by harvesting (cutover).

Stress Indicators under construction include:
Irrigation Indicator;
Landfill Indicator;
Contaminated Sites Indicator;
Oil and Gas Spills Indicator;
Environmental Impact Assessments Indicator;
Pipeline Crossings of Streams Indicator; and
Industrial Waste Discharge Indicator.

7.2 Condition Indicators

Water Quality Index

What is this indicator, and why is it important?
This indicator reports on the water quality of an individual water body within a watershed. The Water Quality Index is an assessment of the chemical and biological constituents within the water.

Good quality water is essential for human health, aquatic ecosystems and economic growth. Water quality is primarily affected by: 1) point and non-point pollution; 2) land-use and land management practices; 3) modifications to flow rates caused by control structures, such as dams, weirs and other man-made systems that modify how water moves downstream; and 4) in-lake or in-stream biological processes (i.e. the biological community within the water itself can have a feedback that affects water quality. This is important to note because changes in a community structure can have detrimental or positive effects on water quality) (Environment Protection Authority, New South Wales 2003).

Water quality monitoring is a core area of the Saskatchewan Watershed Authority's mandate.

Measure: The Water Quality Index (WQI) is an effective means for summarizing a large number of water quality parameters.

In the Water Quality Index, values for various water quality parameters (e.g. dissolved oxygen, nutrients, fecal coliform) are compared to specific water quality objectives. The results of the comparisons are combined to provide a water quality ranking (e.g. Good, Fair, Poor) for individual water bodies. The advantages of an index include: its ability to represent measurements of many water quality parameters in a single number; its ability to combine numerous parameters with different measurement units in a single number; and its effectiveness as a communication tool. When the same objectives and variables are used, the index can be used to convey relative differences in water quality between sites. Care must be taken when comparing among sites because of natural variability in water quality constituents (e.g. a naturally saline lake would naturally have high concentrations of dissolved ions compared to a freshwater lake). Disadvantages of using the index include: a loss of information on single variables; the sensitivity of the results to the formulation of the index; the reliance on objectives as a basis for assessing water quality; and the loss of information on interactions between variables.

The index is based on three components that relate to water quality objectives:

Scope - How many? - The number of water quality variables that do not meet objectives in at least one sample during the index period under consideration relative to the total number of variables measured.
Frequency - How often? – The number of individual measurements that do not meet objectives, relative to the total number of measurements made in all samples for the index period of interest.
Amplitude - How much? - The amount by which measurements which do not meet their objectives depart from those objectives.

Rating Scheme:
The Water Quality Index values range between 0 and 100, with zero representing the worst water quality and 100 representing the best water quality. Once the WQI value has been calculated the value can be further simplified by assigning it to one of several descriptive categories:

Excellent: (WQI value 95-100) – Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.

Good: (WQI value 80-94) – Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair: (WQI value 60-79) – Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal: (WQI value 45-59) – Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor: (WQI value 0-44) – Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

For this document condition indicators are grouped into three categories: Healthy, Stressed, and Impaired. Therefore, for this indicator the WQI categories have been grouped together into the following three categories:

Water Quality Index
Healthy - Water Quality Index has a value between 80 and 100.
Stressed – Water Quality Index has a value between 45 and 79.
Impaired – Water Quality Index has a value less than 45.

Data:

The Water Quality Index was calculated for six stations along the Qu'Appelle River. The earliest data is from 1969 collected at the site above Wascana Creek and at the Lumsden site, which is immediately downstream from the confluence of Wascana Creek and the Qu'Appelle River. Data for all other sites starts in 1973. The average WQI from 1969/1973 to 2002 is given in Figure 21.

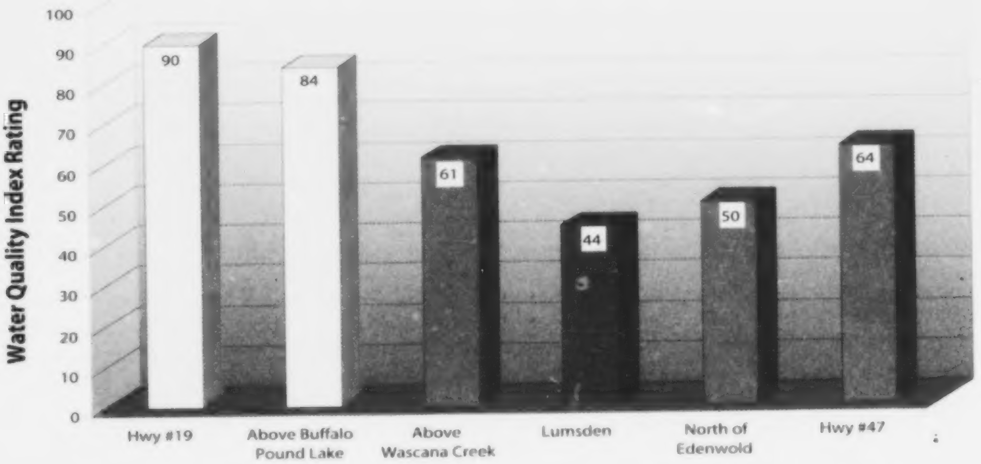


Figure 21. Average Water Quality Index values from 1969/1973 to 2002 for the six sampling stations along the Qu'Appelle River.

Data Source: Water Quality Index values were obtained from the Esquadat database maintained by Saskatchewan Environment.

Data Handling: Data was averaged from 1969 to 2002 for the sites Above Wascana Creek and at Lumsden, and from 1973 to 2002 for the other sites.

Discussion: Water quality is rated as being Healthy at Highway #19 and above Buffalo Pound Lake. There is a decrease in the WQI around Wascana Creek and Lumsden to Stressed and Impaired, respectively. A slight improvement in water quality occurs further downstream on the Qu'Appelle River.

Surface Water Quantity Indicator

What is this indicator, and why is it important?
This indicator measures how much of the surface water resource is available to meet multiple objectives such as human consumption, watershed health, and economic activities like industrial uses, power generation, and agriculture. Water quantity available for use includes surface water, groundwater, and considerations of in-stream flows.

Measure: Surface water quantity is the amount of surface water within a watershed. The water available for use can be roughly estimated by subtracting the sum of water allocations within a watershed and the downstream obligations (whether apportionment or in-stream) from the estimated natural runoff volume. If a watershed is part of an interprovincial or international basin, Saskatchewan must pass on 50% of the natural flows to the downstream jurisdiction. In the case of major streams crossing international or interprovincial boundaries, the supply available (annual median runoff) would be based on the current supply received minus the existing allocations and downstream obligations (see Appendix 2 for basin multipliers). In either case we should use allocations rather than actual use.

Net Available Surface Water = Annual median runoff x Downstream allocations (Basin multiplier) - Instream allocations

Data:

Table 15. Sample calculation of Net Available Water for the Assiniboine River Basin using the Saskatchewan Rural Water Mapping Initiative.

Median runoff volume (unit runoff x area)	**291,908 dam^3**
Downstream allocations (Basin multiplier = 0.5)	145,954 dam^3
Internal allocation for projects in the basin	31,427 dam^3
Net Water Availability	**114,527 dam^3**

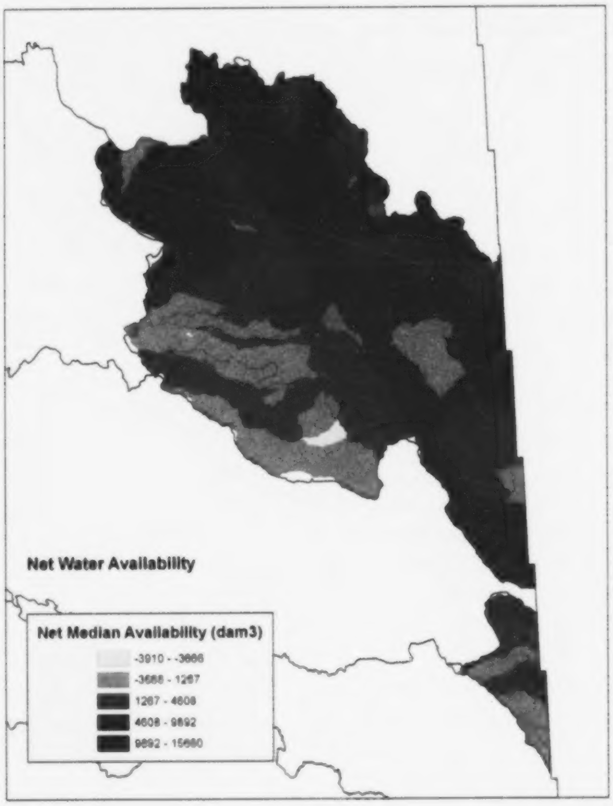


Figure 22. The Saskatchewan Rural Water Mapping Initiative's Net Water Availability in the Assiniboine River Basin.

Data Source: The unit runoff volumes were obtained from Environment Canada's hydrometric stations (http://www.wsc.ec.gc.ca/). Internal surface water allocations were obtained from the Saskatchewan Watershed Authority's Surface Water Database. Net water availability was obtained from the Saskatchewan Rural Water Mapping Initiative. The Saskatchewan Rural Water Mapping Initiative is a tool for surface water resource planning developed by a multi-agency team, lead by the Prairie Farm Rehabilitiation Administration.

Data Handling: The annual runoff volumes recorded at all hydrometric stations were patched through correlations with records of stations in adjacent watersheds. This assumes that the data is representative and that upstream uses do not change. The median runoff data was interpolated to form a provincial grid of median annual runoff. These can be used to obtain runoff volumes by multiplying by watershed area.

Data Quality/Caveats: Allocation does not necessarily mean a net loss to the system because typically the full allocation is not used or there is a return of some of the water back to the system.

Discussion: This indicator should be sensitive to climatic variability affecting natural supply, changing water allocations, and increasing recognition of in-stream flow needs. Total water availability would include groundwater supplies and allocation, but it is not currently possible to estimate this. This indicator requires further development.

Groundwater Quantity Indicator

What is this indicator, and why is it important?

This indicator reports on the groundwater supply potential. Groundwater is a primary source of drinking water for the majority of the rural consumers because of its availability over large geographic areas and because of generally lower treatment costs. An adequate supply of groundwater is not only necessary to supply drinking water demands, but it is also an important resource for industry, irrigation, and agriculture. The Saskatchewan Watershed Authority is responsible for managing and protecting groundwater as source water and for regulating its use through allocation.

Narrative: Quantifying groundwater is typically challenging. The actual quantity of water available for use is difficult to estimate and money available for groundwater research is limited. Therefore, a secondary or surrogate factor such as total groundwater use or observation well data is used to estimate the state of our groundwater sources. Groundwater use data provides an indication of the stress put on the resource, while observation data indicates the state of the net available water (total available water less any uses) in the few aquifers for which data is available.

Any groundwater use with the exception of domestic use requires approval pursuant to the *Saskatchewan Watershed Authority Act*. These uses include municipal, industrial (including groundwater de-watering), intensive livestock operations, commercial, public institutions, and irrigation projects. Whether or not an aquifer can support a particular use is determined from test drilling, analysis of associated geologic and hydrogeologic information, and by pump testing the well. A groundwater investigation is required by the proponent to ensure that the groundwater source can sustain the proposed development without any adverse impacts on the source or on existing groundwater users. The regulatory process ensures the sustainability and environmentally sound management of groundwater resources in Saskatchewan.

The Saskatchewan Watershed Authority and the Saskatchewan Research Council (SRC) have established an observation well network to monitor changes in specific aquifers around Saskatchewan. The network was established in 1964 with the initial intention to measure natural fluctuations in groundwater levels. Sites were selected based on their geohydrological variety and in aquifers where SRC was involved in more detailed geohydrological activities.

Figure 24 illustrates the spatial distribution of the observation network. The range of fluctuations in water levels is still not well understood, as less than 40 years of monitoring information has been collected. In 1988, the Saskatchewan Watershed Authority initiated a second observation network to monitor water levels in areas of high development, such as the Regina and Yorkton area aquifer systems.

Data:

Water level measurements from observation wells located throughout Saskatchewan are in digital format. These water level measurements are illustrated as hydrographs. At present, there are 72 observation wells located throughout Saskatchewan. Of the 72 wells, 54 were previously monitored by the Saskatchewan Research Council (SRC) and 18 by the Saskatchewan Watershed Authority. As of April 1, 2005 the Saskatchewan Watershed Authority assumed responsibility for the observation wells operated by SRC. To date, the Saskatchewan Watershed Authority is responsible for the 72 active observation wells located throughout Saskatchewan. These hydrographs are updated bi-annually. A brief description and information for each observation well can be obtained through the Saskatchewan Watershed Authority's website (http://www.swa.ca/WaterManagement/Groundwater.asp?type=ObservationWells).

General information regarding groundwater and water wells is available to the public. Potential water bearing zones are interpreted using past drilling information, water chemistry, and the geology and groundwater resource maps. The information provides general guidance to the public for the water supply potential at a given location.

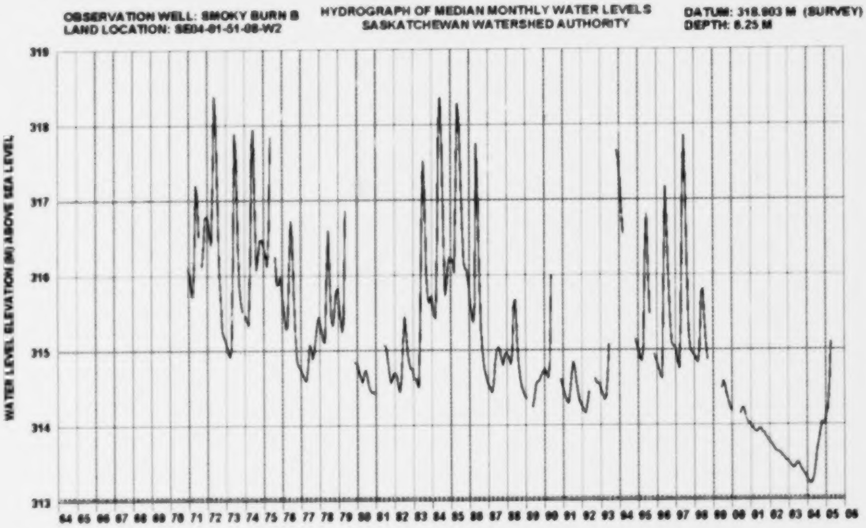


Figure 23. Example hydrograph of groundwater levels at Smokey Burns.

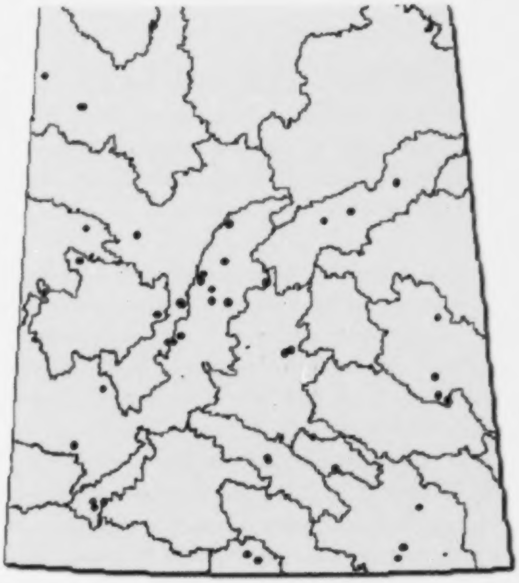


Figure 24. Spatial distribution of observation well network.

Data Source: The hydrograph of median monthly groundwater levels at Smokey Burns was obtained from the Saskatchewan Watershed Authority. Smokey Burns is one of the 72 wells monitored by the Authority through the observation well network.

Riparian Health Indicator

What is this indicator, and why is it important?

This indicator measures the ability of a riparian area to perform the essential functions of: improving water quality through the filtration of nutrients and contaminants from runoff; reducing erosion by dissipating stream and wave energy associated with high water levels; trapping sediment and capturing streambed load; stabilizing streambanks and shorelines; ground water recharge; and enhancing aquatic and terrestrial habitat (Hansen et al. 2000).

A riparian zone is the interface between terrestrial and aquatic ecosystems, including the terrestrial areas adjacent to water bodies that are influenced by elevated water tables or flooding (and by the ability of the soils to hold water).

Measure: The lotic (flowing water) and lentic (still water) riparian health assessments developed by Hansen et al. (2000) utilize vegetation, soil and hydrology factors to assess the functional ability, as well as management and ecological considerations of the riparian area. The biotic and abiotic information is weighted, combined, and rated to produce an overall assessment of riparian health. This assessment method has been widely used in the midwestern United States and in Western Canada.

Rating Scheme:

The riparian health assessment ratings range from 0% to 100%, with 0% representing an Impaired riparian area and 100% representing a Healthy riparian area in Proper Functioning Condition (see Hansen et al. 2000).

Riparian Health

Healthy (Proper Functioning Condition): (80-100%) - Riparian area performs all of its functions and is considered to be stable.

Stressed (Function at Risk): (60-79%) - Riparian area performs many functions, but signs of degradation are visible.

Impaired (Non-Functional): (Less than 60%) - Riparian area has lost most of its ability to perform its functions and is now considered to be degraded.

Data:

Table 16. Riparian assessments by watershed pre-2002.

Watershed	Lotic assessments	Lentic assessments
Assiniboine River	50	13
Big Muddy Creek	7	153
Carrot River	5	0
Cypress Hills North Slope	19	1
Eagle Creek	5	2
Lake Winnipegosis	1	2
Lower Qu'Appelle River	64	2
Lower Souris River	50	7
Milk River	34	2
Moose Jaw River	31	46
North Saskatchewan River	25	7
Old Wives Lake	54	59
Poplar River	18	0
Quill Lakes	3	0
South Saskatchewan River	51	15
Swift Current Creek	68	1
Upper Qu'Appelle River	75	12
Upper Souris River	74	30
Wascana Creek	12	0
Total	**646**	**352**

Sample Analysis: *Upper Qu'Appelle River*

In 2003, 191.11 hectares comprising 102.39 river kilometres on the main stem of the Upper Qu'Appelle River were assessed for riparian health. The average overall riparian health score for the 73 assessed areas was 56%, which falls in the Impaired (Non-Functional) rating. The average soil score was 50% [s = 24% (s = standard deviation)] and the average vegetation score was 69% (s = 12%).

Table 17. Riparian health summary for the Upper Qu'Appelle River main stem.

Overall rating	River kilometres	Percent of assessed length
Healthy	12.50	13
Stressed	29.06	30
Impaired	55.35	57

Data Source: Between 1996 and 2002 the Saskatchewan Watershed Authority conducted 830 short-form lotic health assessments and 544 short-form lentic health assessments. A short-form riparian health assessment provides a rapid snapshot of the health of a riparian area. Long-form riparian health inventories have been conducted on the Upper Qu'Appelle and the Quill Lakes; riparian classification has been done on 312 stands throughout Saskatchewan (Thompson and Hansen 2001). A riparian health inventory is a comprehensive ecological study of a particular site. The inventory documents detailed information about the plant community, soil and hydrology of the site. Table 16 is a partial tabulation by watershed of those assessments. (Note: there are another ~55% (count = 756) assessments that have been conducted but still need to be finalized).

Data Quality/Caveats: Significant effort is required to determine riparian health and stream stability baselines and trends, as each riparian assessment requires 1 to 2 hours per site to complete. Current riparian assessments do not address forestry impacts and issues.

Discussion: This measure will reflect both land management and flow management responses. Development of this indicator transcends divisional and unit boundaries within the Saskatchewan Watershed Authority and will require significant corporate commitment to obtain meaningful assessments.

Riparian Buffer Indicator

What is this indicator, and why is it important?
This indicator reports on the percent of permanent cover within a 40 m buffer of a waterway. Riparian buffer strips of permanent vegetation are a widely recommended land management technique to protect source water. Vegetated riparian buffers help perform the essential functions of a healthy riparian area.

The effectiveness of riparian buffers in protecting water quality depends on many factors, including vegetation type and vegetation width, soil type, slope, adjacent-land uses, and type of potential contaminant. The majority of factors influencing the effectiveness of riparian buffers are site specific and usually cannot be quickly assessed. Most scientific research and management recommendations focus on buffer widths to assess the effectiveness of a buffer for protecting water quality.

Measure:

$$\text{Percent Riparian Buffer (PRB)} = \frac{\text{Area of permanent cover within a 40 m buffer of a waterway (m}^2\text{)}}{\text{Total area of buffer (m}^2\text{)}}$$

Rating Scheme:
The Percent Riparian Buffer (PRB) ranges from 0 to 100, with a value of 0 representing a riparian area that has been cleared of all vegetation within 40 m of the water body and 100 representing a riparian area that has permanent land cover throughout the 40 m buffer.

The rating system is based on studies and literature reviews conducted by Osborne and Kovacic, 1993; Castelle et al., 1994; Dosskey, 2001; Broadmeadow and Nisbet, 2004.

Percent Riparian Buffer
Healthy (30 m and over): (PRB value > 72.5) - A buffer width within this range maintains the physical, chemical and ecological components of many wetlands and streams, and has consistently high percent reduction of nutrients/sediment and pesticides.
Stressed (Between 10-29 m): (PRB value 25.1 – 72.5) - A buffer width within this range has consistently high percent reduction of nutrients, sediment and pesticides, but it is not sufficiently wide to protect the ecological integrity of the water body.
Impaired (Less than 10 m): (PRB value 0 – 25) - A buffer width within this range is considered unstable and unsustainable. It is unable to provide adequate shade and moderate stream temperatures, and it is highly variable in percent reduction of NO3- - N, Total N, PO43- -P, Total P, sediment and pesticides.

Data:

This indicator was calculated for sub-basins in the Souris and Qu'Appelle River Basins.

Table 18. Percent permanent cover in 40 m buffer of streamcourses.

Sub-basin	Percent Riparian Buffer
Antler River	45
Four Creeks	59
Long Creek	33
Moose Mountain Creek	48
Pipestone Creek	47
Souris River	40
Average for Souris River	**44**
Lanigan Creek	24
Little Manitou Lake	31
Last Mountain Lake	25
Upper Qu'Appelle River	45
Average for Qu'Appelle River	**46**

Data Source: The Saskatchewan Western Grain Transition Payment Program Landcover classification and Saskatchewan Stream Network (SSN) were used in the calculation of this indicator. The Southern Digital Land Cover (SDLC) should not be used because it is filtered and the buffer width is only two pixels wide.

Data Handling: The percent permanent cover was measured by drawing a 40 metre buffer on either side of the streamcourse. Forage, grassland, shrub, and tree classes from the Western Grain Transition Payment Program Landcover were lumped together into a class called permanent cover.

Discussion: Buffer width is the sole criterion used to measure Percent Riparian Buffer (i.e. soil type, slope, and vegetation type were not included in the calculation). It is possible that a riparian area with a Percent Riparian Buffer rating of excellent may have a riparian health assessment rating of unhealthy. Therefore, it is important that this indicator be validated with the Riparian Health Indicator. Castelle et al. (1994) identify four criteria for determining appropriate buffer widths: (i) resource value; (ii) intensity of adjacent land use; (iii) buffer characteristics; and (iv) specific buffer functions. Typically, a narrower buffer area may be adequate to protect a water body when the riparian area is healthy and the adjacent-land use has a low impact potential (i.e. parkland, low density residential, shallow slopes, or non-erosive soils). Larger buffer areas may be required for high value resources, where the riparian area is unhealthy, where soils are less permeable or highly erodible, slopes are steep, or where the adjacent-land use is intense (e.g. intensive agriculture).

It should be noted that the Percent Riparian Buffer measure has the potential to cause inaccuracies in buffer placement around lakes, as it is calculated using the Saskatchewan Stream Network, not data from the actual water bodies.

The average Percent Riparian Buffer width for select waterbodies in the Souris River and Qu'Appelle River Basins (Table 18), fall into the Stressed watershed health condition category.

Rangeland Health Indicator

What is this indicator, and why is it important?

This indicator measures the ability of a rangeland to perform the essential functions of reducing soil erosion, increasing water infiltration and reducing runoff.

Rangelands consist of indigenous or introduced vegetation that is either grazed or has the potential to be grazed. Healthy rangelands maintain a diversity of plant species, including grasses, herbs, shrubs and trees through the efficient cycling of nutrients and capture and slow release of moisture. They also function to improve water quality by reducing sediment deposition and soil erosion (Adams et al. 2003).

Measure: Traditionally rangelands have been evaluated using the Range Condition Method. This method compares the resemblance of the present composition to that of an ecologically desirable composition. In the last few years range health methods that measure ecosystem function have been widely adopted across North America (Pellant et al. 2000).

Rating Scheme:
The rangeland health assessment ratings range from 0% to 100%, with less than 50% representing an Impaired range and a score of 75% or more representing a Healthy range (see Adams et al. 2003).

Rangeland Health
Healthy: (A health score of 75 to 100%) - All of the key functions of a healthy rangeland are being performed.
Stressed: (A health score of 50 to 74%) - Most but not all key functions of a healthy rangeland are being performed.
Impaired: (A health score of less than 50%) - Few of the functions of a healthy rangeland are being performed.

Data:

Table 19. Summary of rangeland health assessments for the Lower Souris River Watershed.

	Number of assessments	Average score	Overall rating
	15	**86.00**	**Healthy**
	16	**62.79**	**Stressed**
	12	**38.75**	**Impaired**
Total	**43**	**64.18**	**Stressed**

Data Source: The range health assessments for the Lower Souris River Watershed, summarized in Table 19, are a compilation of assessments conducted by a number of agencies.

Data Quality/Caveats: At the present time we do not have sufficient data to assess individual watersheds, as the range health assessments which have been collected over the last few years are in separate databases, filing cabinets and computer disks from different agencies.

Most of the rangeland species compositional data available in the province is being compiled by Saskatchewan Research Council into a single database. This information could be used to assess range condition. Currently there is insufficient information to assess range health (Etienne Soulodre, Pers. Comm.).

Data Discussion: For the last few years range health methods have been informally used to evaluate rangelands in Saskatchewan. Saskatchewan Agriculture and Food's Land Branch also has an in-house rangeland health assessment that they have been using for a few years.

Through the Prairie Conservation Action Plan (PCAP), nine different Saskatchewan agencies have been working together to adapt Alberta's range health assessment methods (Adams et al. 2003) for Saskatchewan. Once these methods are developed many agencies within Saskatchewan will be using the same assessment methods [including Saskatchewan Watershed Authority, Saskatchewan Agriculture and Food, Saskatchewan Environment, Nature Conservancy of Canada, Ducks Unlimited Canada, Saskatchewan Research Council (SRC), Saskatchewan Assessment Management Agency, Nature Saskatchewan, and Prairie Farm Rehabilitation Administration (PFRA)].

The basis of this range health analysis is the ecological site description/community classification (reference conditions). PCAP has obtained funding from Greencover Canada Technical Assistance Component for the SRC to develop this site description. Several agencies are pooling data to assist the SRC in developing an ecological site description. This data will be compiled in a database with tens of thousands of previously assessed sites, ranging from the 1950's to present, allowing temporal changes to be observed. Most of the data will be species compositional data only and will not have the other variables needed to assess complete range health. This database will eventually be housed with Saskatchewan Environment.

Discussion: The results of the 43 rangeland health assessments, found in Table 19, were averaged and yielded a score of 64.18. This represents a rating of Stressed.

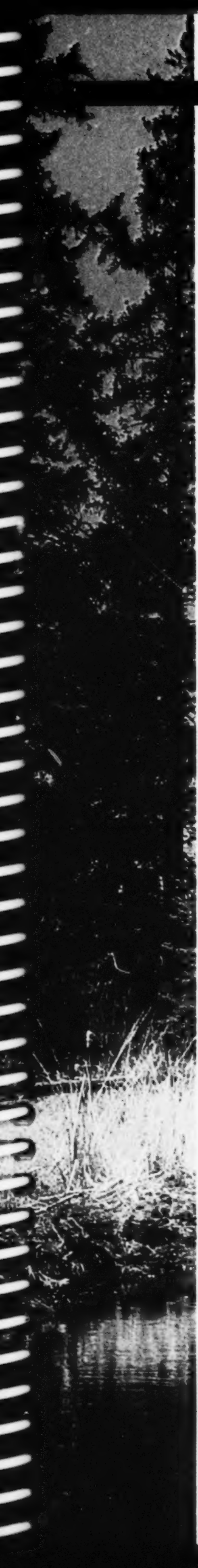
Permanent Cover Indicator

What is this indicator, and why is it important?
This indicator estimates the percent of permanent cover within southern Saskatchewan watersheds. Permanent cover is linked to a watershed's capacity to provide a number of functions such as maintenance of biodiversity, clean water, and reduced flooding potential.

The term "permanent cover" is used in southern Saskatchewan to describe patches of native and tame vegetation that are either never or infrequently cultivated (less than once every 10 years). In southern Saskatchewan cropland represents the majority of watershed area without permanent cover. While differences exist among types of permanent cover, in general, permanent cover in Saskatchewan maintains higher levels of biodiversity and supports more Species at Risk than cultivated cropland.

While significant relationships between permanent cover and clean water and flood reduction have been demonstrated elsewhere, the relationship between these parameters and the magnitude of their effect have not been investigated in Saskatchewan. Similar relationships between permanent cover and aquatic habitat are possible, but require further research in Saskatchewan. Documentation of critical thresholds for the relationships between permanent cover and these parameters would enable managers to identify, and target permanent cover goals appropriate to individual watersheds.

Landscape metrics such as patch size, shape, and connectivity may influence the quality of habitat patches for biodiversity. There is a strong relationship in the southern watersheds between percent permanent cover and mean patch size (Figure 25). Given the ease with which percent permanent cover may be interpreted, its use is preferable.



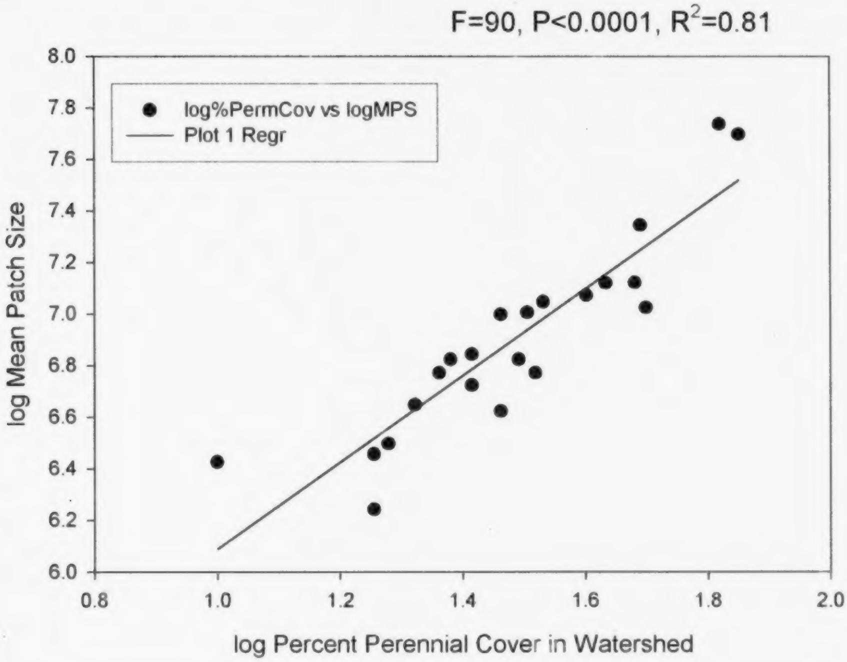


Figure 25. Relationship between percent permanent cover and mean patch size.

Measure:

$$\text{Permanent Cover} = \frac{\text{Area of forage (ha)} + \text{Grassland (ha)} + \text{Shrub (ha)} + \text{Tree (ha)}}{\text{Total area of watershed (ha)} - \text{Area of water in watershed (ha)}}$$

Rating Scheme:

Insufficient data from appropriate scientific studies existed to rate this indicator. So, the Jenks' optimization method was used to find the natural breaks in the data.

Permanent Cover
Healthy: More than 46% of the watershed area is permanent cover.
Stressed: Between 27% and 46% of the watershed area is permanent cover.
Impaired: Less than 27% of the watershed area is permanent cover.

Data:

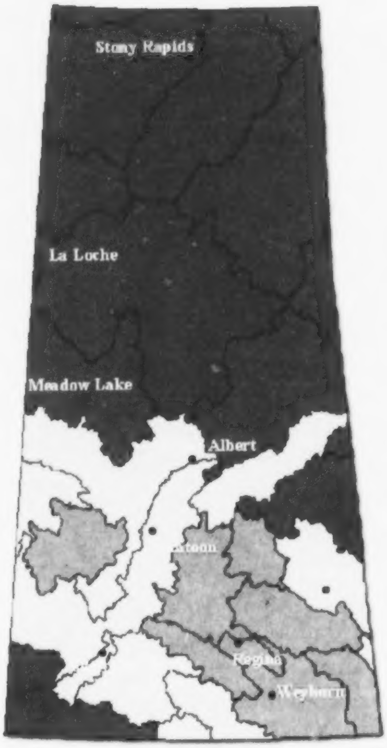


Figure 26. Estimated percent of permanent cover by watershed.

Data Source: Land cover is derived from the Saskatchewan Western Grain Transition Payment Program Landcover classification of 1994 LANDSAT-TM imagery at 30 m resolution.

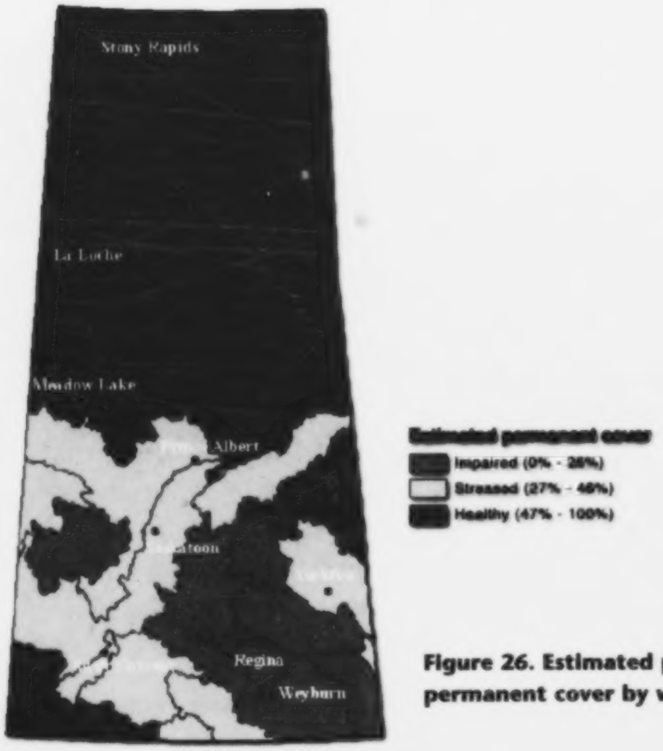
Data Quality/Caveats: This landcover classification is available only for the southern watersheds. Northern watersheds with minimal or no coverage were deleted from this analysis. Watersheds that straddle the northern agricultural fringe of Saskatchewan (including: Beaver, Saskatchewan, Carrot, and Lake Winnipegosis Rivers) and have only partial landcover classification (imagery was acquired for the agricultural portion of the province) have been retained in the analysis with the assumption that the remainder of the watershed has permanent cover.

Data Discussion: Undoubtedly the amount of permanent cover has changed since 1994, likely increasing in many watersheds. Temporal comparisons of permanent cover will not be possible until an update to the Saskatchewan Western Grain Transition Payment Program Landcover has been completed. Given the greatly reduced cost of LANDSAT-TM imagery, and increased processing power of computers and classification software, the probability of a new landcover classification being developed in the near future is great.

Discussion: Seventy percent of the watershed area has landcover information. Of the watersheds with landcover information, on average, 38% of the terrestrial watershed area has permanent cover. Watersheds that have an Impaired rating for permanent cover include Eagle Creek, Lower and Upper Qu'Appelle River and Lower and Upper Souris River, Moose Jaw River, Quill Lakes and Wascana Creek.

Global, national and provincial agricultural economic forces and conservation/preservation policies are the major determinants of temporal change in the permanent cover indicator. Conservation (e.g. North American Waterfowl Management Plan) and preservation (e.g. protected area designation) efforts generally make only small contributions to changes in the permanent cover indicator at a provincial scale, but efforts targeted to specific watersheds may produce measurable change over time.

Data:



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Condition Indicators under construction include:
Species at Risk Indicator;
Invasive Species Indicator;
Wetlands Indicator; and
Benthic Macroinvertebrate Community Assemblages Indicator.

7.3 Response Indicators

Water Conservation Indicator

What is this indicator, and why is it important?
This indicator reports on the water conservation methods employed within Saskatchewan. Some of the benefits of efficient water use include improving water quality, maintaining aquatic ecosystems, sustaining economic growth and protecting drinking water resources.

A water conservation strategy for the Province of Saskatchewan is currently being developed by the Saskatchewan Watershed Authority in consultation with the public and interest groups. The resulting water conservation plan will encourage all sectors (municipal, industrial, and agricultural) to strive toward efficient water use.

There is a broad range of water conservation tools that will be employed within Saskatchewan's Water Conservation Plan, including: 1) communication and educational tools; 2) operational and maintenance tools; 3) economic and financial tools; and 4) institutional support.

Examples of water conservation measures include:

- **Providing educational information on water conservation to the public.**
  Experts within industry have stated that water conservation is a generational shift in attitudes. It is important to start educational/extension activities at an early stage of any water conservation plan.

- **Universal metering.**
  Employed with a volume-based pricing structure, water metering is a good water conservation practice, as it provides a measure of the actual water use of consumers. According to the 2001 Environment Canada Municipal Water Use Survey, of the 78 Saskatchewan municipalities that responded to the survey, 98.5% of residential clients and 99.6% of business clients served by municipal water systems were metered. Saskatchewan had the highest percentage of residential clients that were metered in Canada, according to the 2001 Municipal Water Use Survey results.

- **Water accounting and loss control.**
  This measure will encourage communities to conduct water leak audits. By conducting a water audit communities will be able to determine water loss that may be due to water distribution system leaks.

- **Costing and pricing.**
  Water rate structures can promote conservation by communicating the true cost of water to the consumer through price incentives. The true cost of treated water includes: the cost of the utility to operate; the cost of the utility to increase its water supply to meet growing demand; and the social and environmental costs caused by the water withdrawal. A typical example of a water rate structure that encourages conservation is implementation of an increasing rate structure (if an

excessive volume of water is used, the price for the additional water is increased) compared to a stable rate structure (same cost per cubic metre regardless of how much is used).

- **Promoting the purchase and use of water efficient fixtures.**
- **Developing pilot projects with water efficient practices.**
- **Developing, in conjunction with industry associations, Industry Recommended Practices (IRPs).**

An objective of the State of the Watershed Reporting Framework is to provide an indicator that reports on the water conservation tools that can be instituted locally within an individual watershed or multiple watersheds.

Measure: An efficiency measure of water uses such as irrigation, municipal, and industrial water uses will provide historic baseline water use information.

$$\text{Municipal Conservation} = \frac{\text{Daily municipal use per capita (litre/person/year)}}{\text{Municipal population}}$$

$$\text{Irrigation Conservation} = \frac{\text{Irrigation (dam}^3\text{)}}{\text{Irrigated acres}}$$

$$\text{Industrial Conservation} = \frac{\text{Number of industries implementing Industry Recommended Practices}}{\text{Number of Industry Recommended Practices completed}}$$

Due to the inconsistency in how irrigation is monitored however, it makes more sense to provide a qualitative overview of delivery methods used in a basin and to describe the advantages of these types to water conservation (e.g. low pressure systems may be better for conservation than high pressure systems).

Data:

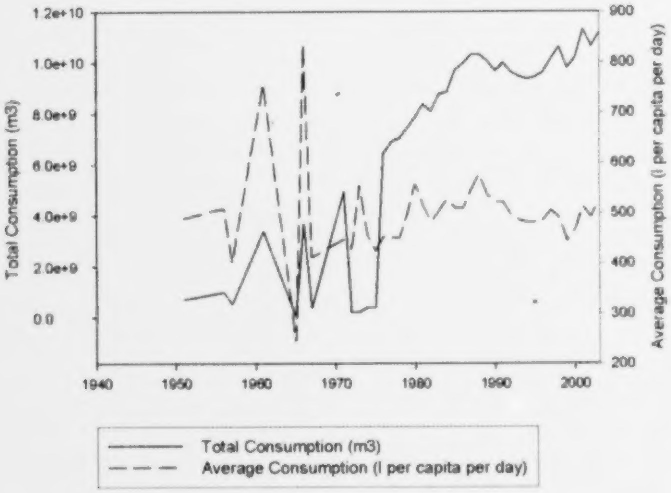

Figure 27. Estimate of per capita daily water consumption in the South Saskatchewan River Basin.

Table 20. Irrigation projects in the South Saskatchewan River Basin.

Irrigation project	Year	Irrigated acres	Irrigated volume (Acre feet)	Irrigated feet
South Saskatchewan River Irrigation District	2003	33,973.7	41,246.5	1.21
Gravity Open Ditch	2004	35,213.7	24,436.3	0.69
Riverhurst	2003	9,538.3	9,080.27	0.95
Pressurized	2004	9,869.6	4,411.42	0.45
Luck Lake	2003	8,602.20	3,407.83	0.40
Pressurized	2004	8,602.20	8,252.9	0.96

Data Source: The waster consumption data was obtained from the Saskatchewan Watershed Authority's Community Consumption Database. Population information was obtained from the *Saskatchewan Health Covered Population 2004* document (Government of Saskatchewan 2004).

Data Discussion: In general, existing data is insufficient to comprehensively quantify water conservation for a basin. Irrigation data is often available for the largest irrigation projects, as shown for the three large irrigation districts in the South Saskatchewan River basin. The new metering and billing database of SaskWater may have some potential for this indicator.

Consideration must be made of drought situations that may create a false measurement of any conservation. If water supplies are adequate, irrigation will increase during meteorologic drought, falsely indicating reduced conservation. When water supplies are inadequate or during periods of adequate or surplus growing season precipitation, irrigation water use will be reduced, falsely indicating increased water conservation efforts. Time-series analysis of water consumption may eliminate or at least reduce these errors. With municipal conservation, attention must be paid to whether source water is surface or groundwater, and also the accuracy of actual watershed source (i.e. some communities within a watershed may receive source water from an adjacent watershed).

Watershed Education Indicator

What is this indicator, and why is it important?

This indicator reports on the number and type of watershed-related educational programs delivered to school-aged youth. Sustainable watershed management is premised on stakeholders being knowledgeable about their watershed. Educational programs can raise awareness of watershed issues and change values and beliefs that people hold of watershed resources. This attitudinal change prefaces behavioural change; people generally try to be consistent in their attitudes and behaviours. The linked behavioural changes are fundamental to promoting sustainability, as the impact of the cumulative actions of individual and group stakeholders in a watershed outweighs those of the Saskatchewan Watershed Authority's direct management.

The success of a watershed education program is measured through increased awareness of watershed issues and behavioural change to support improvements in watershed condition.

Measure: Learning outcomes are difficult to measure. However, there are indirect predictors of learning outcomes that can be easily measured, the easiest being educational effort. The number of programs delivered to school-aged youth, or *Youth Programs*, provides a direct estimate of the number of youth exposed to watershed health-related modules. *Workshop Delivery* measures the number of delivered workshops and the number of attending facilitators. This provides an indirect measure of the potential number of youth exposed to watershed education modules. The number of *Active Facilitators* is an even more indirect predictor of learning outcomes than *Workshop Delivery*, but it does provide insight into how workshops are delivered and perhaps how sustainable that delivery is.

Programs included in this measure are Project WET, Project WILD, and Climate Change Education Saskatchewan (CCES) offered by the Saskatchewan Watershed Authority; the Saskatchewan Wetland Education Program offered by Ducks Unlimited Canada; the Cows, Fish, Cattle Dogs, and Kids Game Show offered by the Prairie Conservation Action Plan; and the Water Watchdog Program offered by Partners FOR the Saskatchewan River Basin.

Data:

1) Project WET (Water Education for Teachers) is an education resource that provides teaching aids and programs for promoting awareness and stewardship of water resources. Project WILD is an educational program emphasizing an understanding of wildlife, ecosystem functioning, and responsible environmental citizenship. Climate Change Education Saskatchewan links climate change information to the science and social studies curricula in Saskatchewan. All three programs are aimed at educators and young people from 5-18 years of age. The primary audiences for these environmental education programs are teachers and pre-service teachers.

Curriculum linkage is the cross-referencing of watershed health issues to the Saskatchewan core curricula. Curriculum linking has already been done for Project WET. Some of the key watershed health issues present in a watershed can be linked at a coarse level to the Saskatchewan curriculum as they are identified in the State of the Watershed Reporting process.

Public awareness can be gauged through *Focus Group Results*. The focus group sessions can involve the Watershed Advisory Committees and/or any formal and informal network of partners and clients. Focus group sessions can provide a qualitative indication of attitudes regarding watershed health issues and common practices. These focus sessions need to happen at the beginning of the planning process and approximately five years later.

Table 21. Environmental education events for Saskatchewan school-aged youth (4-18 years-old) and teacher/parent supervisors: July 2004-June 2005.

Program	Number of events	Number of participants
Project WILD	2	93
Project WET	19	2,387
Project WET – Splash!	3	732
Climate Change Education Saskatchewan*	6*	219*
General Watershed Education	1	12
Totals	**30**	**3,443****

*Climate Change Education Saskatchewan (CCES) was devolved to Climate Change Saskatchewan (CCS) in October 2004.

**More than 500 students per year (and their teachers) attend project WILD and Project WET activities as part of the Eco-Extravaganza delivered by Stewardship Division in partnership with the Prairie Conservation Action Plan. These numbers are not included here.

Table 22. Professional development programs for educators in Saskatchewan: July 2004 to June 2005.

Workshop type	WILD**	Below Zero	WET**	Climate Change (to Oct.'04)	Native Prairie Curricula	Totals
Certification (1 day)	13	N/A	10	N/A	N/A	13
Participants	**300**	-	**199**	-	-	**499**
Certification (0.5 day)	1	1	N/A	5	N/A	7
Participants	**34**	**34**	-	**57**	-	**125**
Leadership Development and/or Curriculum Writing (1-3 day)	2*	1*	2*	N/A	1	7*
Participants	**21**	**12**	**38**	-	**7**	**165***
Mini-Workshops (1-1.5 hr.)	2	N/A	2	1	N/A	5
Participants	**17**	-	**32**	**2**	-	**51**
Total Workshops **Total Participants**						**32**** **860****

*One shared Leadership Development Event – Earth Day Conference - with 87 attendees, 25 students and 50 parents/relatives.

** Four additional workshops with 67 participants were delivered in Manitoba for audiences from the Prairie Provinces and northwestern Ontario.

Table 23. Active facilitators: July 2004-June 2005.

Program	Number of facilitators
Project WILD	20
Project WILD – Below Zero*	4*
Project WET	22
Climate Change Education Saskatchewan** (CCES)	8**
Total Number of facilitators	**54**

* Below Zero Pilot, January 2005.

**Climate Change Education Saskatchewan (CCES) was devolved to Climate Change Saskatchewan (CCS) in October 2004.

2) Ducks Unlimited Canada's Saskatchewan Wetland Education Program was designed for grades one to eight, and was initiated in the 1999-2000 school year. This program includes Ducks Unlimited Canada staff–led wetland field trips and/or in-class lesson plans on wetlands. The new name for the Saskatchewan Wetland Education Program is Project Webfoot. In addition to the Saskatchewan Wetland Education Program, Ducks Unlimited Canada also has the Greenwing Program. The Greenwing Program is a membership-based program geared to school-aged youth. Membership in the Greenwing Program includes a certificate of membership, a subscription to either *Puddler* magazine (aged 12 and under) or *Conservator* magazine (12-17 years-old), and a copy of the *Marsh World* wetland guidebook.

Table 24. Ducks Unlimited Canada's Greenwing members

Fiscal Year	Greenwing members in Saskatchewan
1995-1996	197
1996-1997	566
1997-1998	881
1998-1999	1,050
1999-2000	1,067
2000-2000	843
2001-2002	583
2002-2003	554
2003-2004	464
2004-2005	487

* includes Legacy, senior and junior members but not Adopt-A-Class or school-based programs.

3) The Saskatchewan Prairie Conservation Action Plan delivers the Cows, Fish, Cattle Dogs and Kids Game Show to Grades 4 to 6. The Game Show is an educational game show about riparian areas. The game show is funded by a number of organizations, making it free of charge to participating schools in Saskatchewan's Prairie Ecozone.

Table 25. Prairie Conservation Action Plan Cows, Fish, Cattle Dogs, and Kids Game Show: 1999 to June 2005.

School Year	Number of schools	Number of students
1999-2000	10	800
2000-2001	14	1,200
2001-2002	80	5,400
2002-2003	176	8,375
2003-2004	70	6,500
2004-2005	31	2,735
Total	**381**	**25,010**

4) Partners FOR the Saskatchewan River Basin previously offered, free of charge, the Water Watchdog Program to stewardship groups in Manitoba, Saskatchewan, and Alberta. Partners FOR the Saskatchewan River Basin is currently in the process of pursuing funding to continue offering this program. The Water Watchdog program is a hands-on program geared to young people (7-14 years-old) involved in such organizations as Girl Guides, 4-H, Junior Forest Rangers, stewardship groups, and summer camps. The program incorporates a field trip to a local stream or lake to assess local water quality and riparian conditions. An estimated 200 different prairie water bodies have been monitored by Water Watchdog groups. At least 1,800 adults have worked as Water Watchdog volunteer facilitators.

Table 26. Total participants in the Water Watchdog Program for Alberta, Saskatchewan and Manitoba.

Year	Number of participants
2001	580
2002	1,635
2003	8,550
2004	2,400
2005	560
Total	**13,725***

* Saskatchewan residents account for over 40% of the total participants.

Data Source: Information on the number of participants in Project WET, Project WILD, and Climate Change Saskatchewan was obtained from the Saskatchewan Watershed Authority. Information on the number of participants in the Saskatchewan Wetland Education and Greenwing Programs was obtained from Ducks Unlimited Canada. Information on the number of participants in the Cows, Fish, Cattle Dogs, and Kids Game Show was obtained from the Saskatchewan Prairie Conservation Action Plan. Information on the number of participants in the Water Watchdog Program was obtained from the Partners FOR the Saskatchewan River Basin.

Discussion: The watershed education data can not be disaggregated by watershed. However, the existing data allows the educational response to be measured at the provincial scale.

Livestock Operations Regulations Indicator

What is this indicator, and why is it important?
This indicator reports on the existing livestock operation regulations that are in place to monitor and protect surface and groundwater quantity and quality.

Demand for environmental regulations, particularly those protecting water quality from the adverse effects of intensive livestock operations (ILOs), has been a focal point for legislators around the world (Harker et al. 1998). The Government of Saskatchewan's response has been to amend existing legislation, first through the *Pollution by Livestock Control Act*, (which was revised in 1984) and then in 1995 through *The Agricultural Operations Act*. The Act is used by regulators to determine if a livestock operation requires approval. If approval is required then steps are outlined in order to permit the operation.

The Saskatchewan *Agricultural Operations Act* provides provincial officials additional means to ensure and protect water quality adjacent to ILOs and requires that ILOs obtain and follow manure and dead animal management plans that protect ground and surface water. Small cow/calf producers represent the majority of ILOs impacted by the *Act*. Knopf et al. (2003) estimated that as many as 9,000 cattle operations could require approval under the *Act*; however this number is based on little data.

Since 1971, there have been 2,350 ILO Approvals and Permits issued within Saskatchewan. Of these, 800 are currently listed as operating. As some operations have more than one approval there will be less than 800 active sites. Approximately 15% of the total operations have a status of unknown (Pers. Comm. G. Bayne, 2005).

Measure: This metric will estimate how many of the livestock operations within 300 metres of a surface waterbody (value calculated in the Livestock Operations Indicator), have appropriate mitigation measures in place. If we assume that permitting within the Act reflects appropriate mitigation then we can calculate:

$$\text{Estimated Livestock Operations Within 300 m of Streamcourse} = \frac{\text{Watershed area within 300 m of streamcourse (ha)}}{\text{Total watershed area (ha)}} \times \text{Number of livestock operations}$$

$$\text{Permitted Livestock Operations Ratio} = \frac{\text{Number of permitted ILOs in the watershed}}{\text{Estimated livestock operations within 300 m of streamcourse}} \times 100$$

Data:

Table 27. Percent of livestock operations within 300 m buffer of a waterbody that are permitted within the Lower Souris Watershed.

Sub-basin	Percentage of sub-basin in 300 m buffer of waterbody	Number of livestock operations within the sub-basin	Estimated number of livestock operations within 300 m of a waterbody	Permitted ILOs	Permitted livestock operations ratio
Antler River	17	207	35	8	23%
Four Creeks	13	119	16	13	81%
Long Creek	17	100	17	2	12%
Moose Mountain Creek	21	230	49	42	86%
Pipestone Creek	24	220	54	22	41%

Data Source: The number of livestock operations was obtained from the 2001 Census of Agriculture (Statistics Canada 2002a). Information on the number of permitted intensive livestock operations was obtained from Saskatchewan Agriculture and Food.

Discussion: Based on the calculations in this indicator there are a number of livestock operations within 300 metres of waterbodies within the Antler River and Long Creek Sub-basins that do not have permits and, therefore, have a higher risk of impacting watershed health.

Stewardship

Conservation Stewards Indicator

What is this indicator, and why is it important?
This indicator reports on the number of conservation stewards within a watershed and the number of hectares under conservation agreements. Conservation stewards play a key role in maintaining and conserving natural areas through land management decision-making.

Measure:

Number of Conservation Stewards = Number of conservation stewards per watershed

Number of Hectares Under Agreement = Number of hectares under agreement per watershed

Stewardship information included in this measure is from a number of organizations, including: the Saskatchewan Watershed Authority; Prairie Farm Rehabilitation Administration (PFRA); Ducks Unlimited Canada; and Saskatchewan Agriculture and Food. Stewardship information from other organizations and agencies will be included in this indicator when the data becomes available.

Data:

1) Voluntary stewards who made a verbal voluntary stewardship agreement with the Saskatchewan Watershed Authority through the Prairie Stewardship Program to maintain and protect their native prairie and/or riparian areas to the best of their ability.

Table 28. Number of voluntary stewards and land area covered by the voluntary stewardship agreements under the Prairie Stewardship Program.

Year	Number of stewards	Hectares of prairie	Hectares of wetland	Kilometres of stream
Pre-2002	759	128,906	1,504	80
2002	332	53,049	3,828	220
2003	104	25,736	652	97
2004	77	25,195	1,159	95
2005	69	20,234	365	168
Total	**1,341**	**253,120**	**7,508**	**661**

2) Lake Stewardship Groups who are involved in the Saskatchewan Watershed Authority's Lake Stewardship Program. The purpose of the Lake Stewardship Program is to encourage the collection of water quality data, to share this water quality information with the public, to use the water quality data to improve decision making within the watershed, and to develop partnerships between stewardship groups and other agencies to promote, protect, and preserve water quality and aquatic life (Saskatchewan Watershed Authority Lake Stewardship Fact Sheet).

The Saskatchewan Watershed Authority's Lake Stewardship Program includes eleven stewardship groups. These groups include:

- Stewards of Jackfish and Murray Lakes.
- Friends of Good Spirit Lake.
- Big Shell Lake Watershed Association.
- Brightsand Lake Watershed Association.
- Kelvington Area Round Lake Environmental Stewardship.
- Pipestone Watershed Stewardship Committee.
- Lac Pelletier Stewards.
- Last Mountain Lake Stewardship Group.
- Turtle Lake Watershed Inc.
- Emma/Christopher Lakes Association.
- Anglin Lake Cottage Owners Association.

Water quality samples are taken from thirteen lakes, six times a year, four times in the summer and twice in the winter.

In the summer of 2005, the Lake Stewardship Program adopted the "Living by Water" Program as a pilot project. The purpose of the pilot project is to educate the public about shoreline issues, such as reducing erosion, the benefits of riparian buffers, and how these practices can improve water quality and provide wildlife habitat. To promote this pilot project presentations and home visits were done by the Saskatchewan Watershed Authority's Lake Stewardship Program staff to four of the eleven lake stewardship groups, including: Emma/Christopher Lakes Association; Brightsand Lake Watershed Association; Friends of Good Spirit Lake; and Last Mountain Lake Stewardship groups. There were three presentation topics, including:

i) Learning About Your Shoreline; ii) Shoreline Landscaping and Erosion; and iii) Agriculture, Our Cottage and Us. In total, seven presentations were given, with approximately 100 people in attendance, and 30 home visits were conducted.

Table 29. Number of Lake Stewardship Groups by watershed.

Watershed	Number of Lake Stewardship Groups
Assiniboine River Watershed	1
Lake Winnipegosis	1
Lower Souris River Watershed	1
North Saskatchewan River Watershed	6
Swift Current Creek Watershed	1
Upper Qu'Appelle River Watershed	1

3) Conservation stewards who signed contracts with the Prairie Farm Rehabilitation Administration (PFRA) under the Permanent Cover Program. The Permanent Cover Program I (PCP I) was announced by PFRA as a three-year program in 1989 to reduce the risk of soil erosion on marginal lands that had high erosion potential. An extension to the program was the Permanent Cover Program II (PCP II) which was delivered between 1991 and 1993.

Table 30. Number of contracts signed and hectares converted from marginal cropland to permanent cover under the Permanent Cover Program.

	Contracts	Hectares
PCP I		
10 yr	721	23,425
21 yr	1,097	40,340
PCP II		
10 yr	1,091	34,949
21 yr	2,928	110,361
Total	**5,837**	**209,075**

Source: PFRA, PCP program records

4) Conservation stewards who signed Land Use Agreements with Prairie Farm Rehabilitation Administration (PFRA) under the Greencover Canada Program. Currently, 29,745 hectares in Saskatchewan have been converted to perennial cover through the Greencover Canada Program and are under a Land Use Agreement. Land Use Agreements are 10-year commitments to maintain the land in perennial cover, and they come into effect once the perennial cover is established and inspected. As of August 2005, an additional 74,596 hectares were approved for financial assistance under the program, and either have been, or will be, seeded to perennial cover. At present these lands are not under Land Use Agreements (Pers. Comm. PFRA).

5) Conservation stewards who signed agreements with Ducks Unlimited Canada.

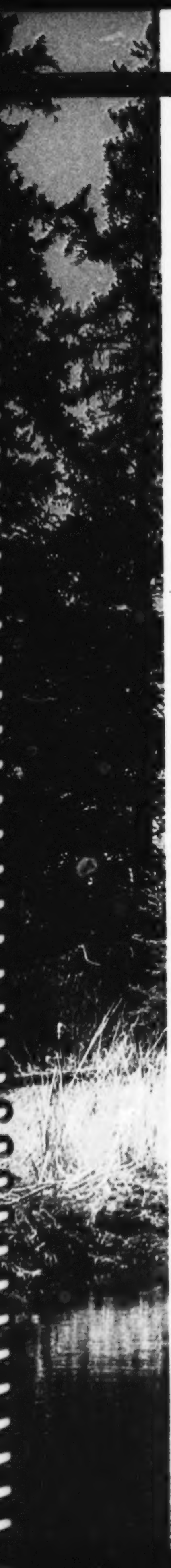

Table 31. Ducks Unlimited Canada Project Summary for the Moose Jaw River Watershed.

	Wetland		Upland		
Securement Method	**# of Segments***	**Wetland hectares**	**# of Segments***	**Upland hectares**	**Total Hectares**
Conservation Easement Projects	6	43	6	140	183
Leased Projects	7	28	7	177	205
Management Agreement Projects	24	542	151	10,757	11,299
Conservation Agreement Projects	41	3,938	4	1,503	5,441
Total	**103**	**5,684**	**204**	**14,428**	**20,112**

**Each project may contain several segments (minimum 2) (i.e. a single project will contain at least one wetland segment and one upland segment).*

**Each segment on a project includes one habitat type or program type.*

**A single project may contain more than one wetland or upland segment (i.e. idled pasture and introduced grass would be two separate upland segments).*

6) Conservation stewards who signed land use agreements with Saskatchewan Agriculture and Food under the Conservation Cover Program. Between 2001 and 2003, the Conservation Cover Program (CCP) provided financial assistance to producers resulting in the conversion of 533,148 hectares of marginal cropland to perennial cover.

Table 32. Number of land use agreements signed under the Conservation Cover Program between 2001 and 2003.

Year	Agreements	Hectares converted
2001	10,792	105,066
2002	6,226	164,311
2003	4,016	263,779
Total	**21,034**	**533,148**

Source: Saskatchewan Agriculture and Food

The land-use agreements and hectares covered by the agreements were mapped by watershed for the data obtained from Saskatchewan Agriculture and Food's Conservation Cover Program (#6, above) and the Saskatchewan Watershed Authority's Prairie Stewardship Program (#1, above). Only two of the five programs were included in this map because they are the only programs for which we currently have georeferenced data.

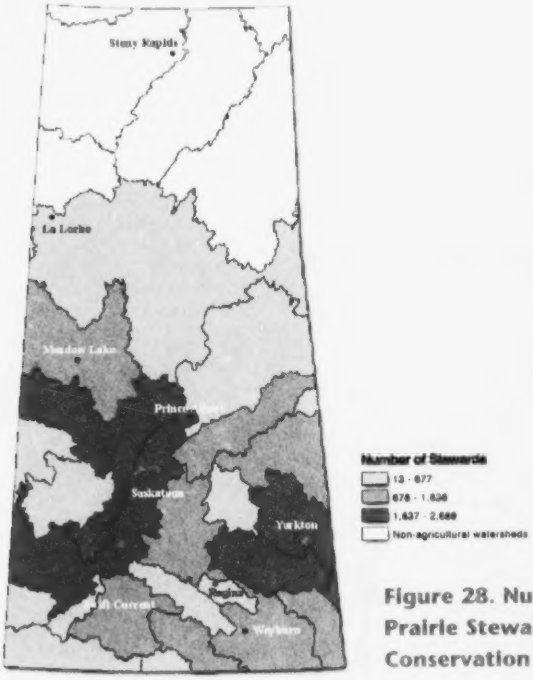
Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Swift Current
Weyburn
Number of Stewards
13 - 677
678 - 1,636
1,637 - 2,689
Non-agricultural watersheds

Figure 28. Number of stewards from the Prairie Stewardship Program and the Conservation Cover Program by watershed.

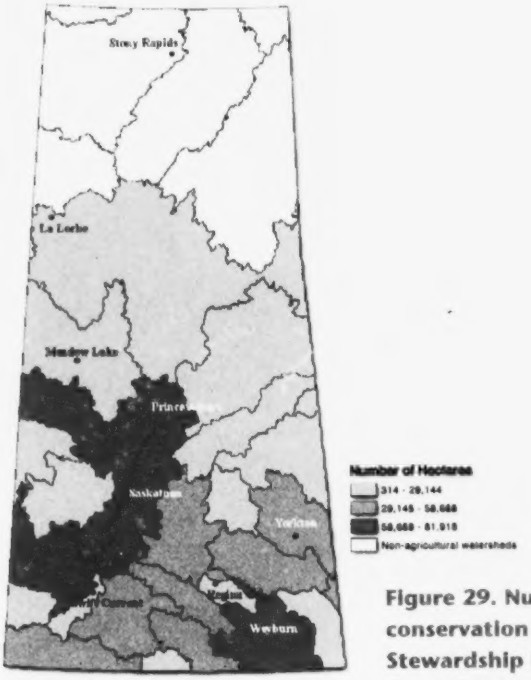
Stony Rapids
La Loche
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Regina
Swift Current
Weyburn
Number of Hectares
314 - 29,144
29,145 - 58,668
58,669 - 81,918
Non-agricultural watersheds

Figure 29. Number of hectares covered by conservation agreements from the Prairie Stewardship Program and the Conservation Cover Program by watershed.

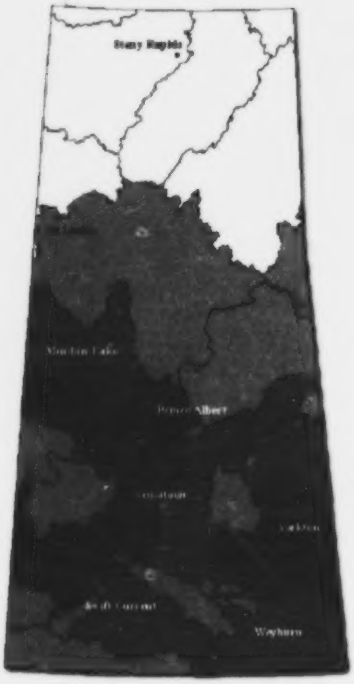
Stony Rapids
Meadow Lake
Prince Albert
Saskatoon
Yorkton
Swift Current
Weyburn
Number of Stewards
15 - 677
Non-agricultural watersheds

Figure 28. Number of stewards from the Prairie Stewardship Program and the Conservation Cover Program by watershed.

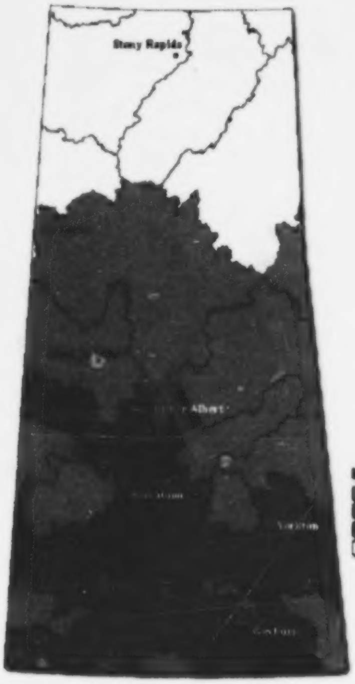
Stony Rapids
Prince Albert
Saskatoon
Yorkton
Estevan
Number of Hectares
Non-agricultural watersheds

Figure 29. Number of hectares covered by conservation agreements from the Prairie Stewardship Program and the Conservation Cover Program by watershed.

Data Source: The number of conservation stewards who made a Voluntary Stewardship Agreement as part of the Saskatchewan Watershed Authority's Prairie Stewardship Program was obtained from the Saskatchewan Watershed Authority's Landowner Information Database. The number of conservation stewards who signed contracts under the Permanent Cover and Greencover Canada Programs was obtained from Prairie Farm Rehabilitation Administration (PFRA). The Ducks Unlimited Canada project summary for the Moose Jaw River Watershed was obtained from the Preliminary Background Report for the Moose Jaw River Watershed (Saskatchewan Watershed Authority 2005). The number of conservation stewards who signed contracts under the Conservation Cover Program was obtained from Saskatchewan Agriculture and Food.

Data Discussion: The intention of this indicator is to map, by watershed, all of the agreements and hectares covered by the different programs. Currently we have mapped by watershed the number of stewards and hectares covered by agreements for the Prairie Stewardship Program and the Conservation Cover Program (Figures 28 and 29). Through the cooperation and collaboration of various organizations, we are currently in the process of obtaining data on additional programs with conservation stewards that will be included in this indicator. We are also summarizing data we currently have by watershed.

Stewardship Workshops Indicator

What is this indicator, and why is it important?

This indicator reports on the number of stewardship workshops per watershed. The land management practices of landowners are critically important to healthy watersheds. Stewardship workshops can be organized to provide stewards with: information on Beneficial/Best Management Practices (BMPs); hands-on training to better understand land management through range and/or riparian assessments; and to showcase the management efforts of specific landowners through field tours.

Measure:

Number of Stewardship Workshops = Number of stewardship workshops per watershed

Data:

1) *The Prairie Stewardship Program.* To increase the public's awareness of the importance, value, and function of riparian and native prairie ecosystems the Saskatchewan Watershed Authority, in partnership with other agencies, initiated the Prairie Stewardship Program in 2002. The Prairie Stewardship Program is an amalgamation of the Saskatchewan Wetland Conservation Corporation's (now Saskatchewan Watershed Authority) Native Prairie Stewardship and Streambank Stewardship Programs. Both the Native Prairie Stewardship and Streambank Stewardship Programs were initiated in 1997.

Prairie Stewardship Program workshops include:

- Field tours to view demonstration projects managed by landowners. Examples of demonstration projects include grazing management systems, perennial forage establishment, and corral/wintering site modifications.
- Range and pasture schools to provide stewards with hands-on training in range or riparian assessments. These intense workshops provide landowners with detailed information on plant identification, ecology and management of riparian and upland ecosystems.

Table 33. Number of Prairie Stewardship Program field days/town hall meetings/workshops and attendance between April 2002 and March 2005.

	Year	Number of events	Attendance
Field days/town hall meetings	2002	19	470
Field days/town hall meetings	2003	6	164
Workshops/town hall meetings	2003	11	280
Workshops/town hall meetings	2004	21	542
Workshops/town hall meetings	2005	7	155
	Total	**64**	**1,611**

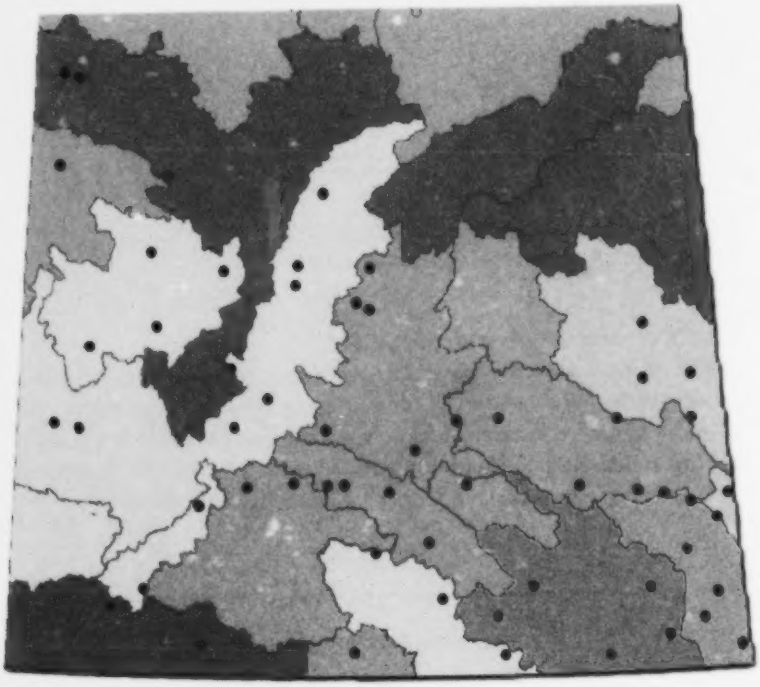

Figure 30. Locations of stewardship workshops delivered through the Prairie Stewardship Program between March 2001-March 2005.

2) *The Environmental Farm Plan Workshops.* To promote Beneficial/Best Management Practices (BMPs) Agriculture and Agri-Food Canada initiated the Environmental Farm Plan Program under the Agricultural Policy Framework (APF). In Saskatchewan, the Environmental Farm Plan Program is delivered by the Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB), in partnership with Saskatchewan Agriculture and Food and Agriculture and Agri-Food Canada. The Environmental Farm Plan Program is comprised of two workshops (Workshop I and Workshop II) delivered by PCAB trained facilitators, followed by a Peer Review process. The purpose of the Environmental Farm Action Plan is to increase the awareness of agricultural producers to some of the risks agricultural land-use practices can have on the environment and to encourage producers to adopt BMPs to reduce these environmental risks.

The Environmental Farm Plan program began in Saskatchewan in September 2004. As of September 22, 2005, there have been 93 Workshop I's with 1,312 participants involved, and 87 corresponding Workshop II's with 771 participants. Six-hundred-and-seventy-three Environmental Farm Plans were submitted for Peer Review, and 655 of these plans were endorsed. Approximately 250 to 280 producers have submitted Action Plans for funding under the Canada-Saskatchewan Farm Stewardship Program. Currently, 11 facilitators have been trained to deliver Environmental Farm Plan workshops. By October 27, 2005, 18 facilitators will be trained to deliver Environmental Farm Plan workshops.

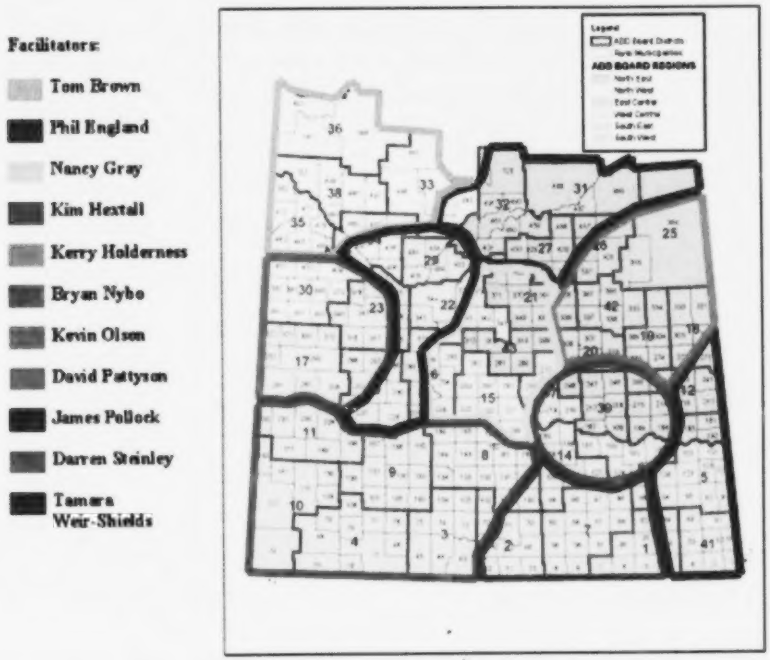
Facilitators:
Tom Brown
Phil England
Nancy Gray
Kim Hextall
Kerry Holderness
Bryan Nybo
Kevin Olsen
David Pattyson
James Pollock
Darren Steinley
Tamera Weir-Shields
Legend
ADD BOARD REGIONS
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Figure 31. Saskatchewan's Environmental Farm Plan workshop delivery areas by PCAB facilitator (September 2005).

Source: http://www.saskpcab.com/locationmap.html

3) *Saskatchewan Soil Conservation Association Workshops*. The Saskatchewan Soil Conservation Association (SSCA) is a non-profit, producer-based organization that actively promotes soil conservation in Saskatchewan through conferences, workshops, a quarterly newsletter, producer networking opportunities, and soil conservation extension materials. The SSCA hosts two conferences annually. In February, the SSCA hosts a Direct Seeding Conference geared to producers, and in December they host a conference geared to crop advisors in the livestock and grain sectors. In addition to the two annual conferences, SSCA staff are guest-speakers at 90 to 100 workshops each year. As guest speakers they provide information on topics such as: crop residue management; crop rotations; weed control; soil fertility; equipment selection and retrofitting; and forages in rotation.

The Saskatchewan Soil Conservation Association's Direct Seeding Conference in February is held in either Saskatoon or Regina. Approximately 650 people attend the Direct Seeding Conference. Of the 650 attendees, at least 500 participants are farmers and the remainder of the participants are crop advisors (agrologists, and agronomists), academics and representatives from the agriculture manufacturing sector. The farmers come from all over the province to attend the conference, although historically more farmers from the north attend the conference when it is in Saskatoon, while more farmers from the south attend the conference when it is held in Regina.

4) *Manure Management Workshops.* A meeting in November 1998 brought together the three prairie provinces to discuss the opportunities for cooperating on research, development and extension activities in the area of Manure Management and Livestock Development.

Saskatchewan Agriculture and Food published their Strategy for Manure Management in early 1999 (http://www.agr.gov.sk.ca/Livestock/pork.asp?firstPick=&secondpick=Pork&thirdpick=Manure%20Management&selection=Manure%20Management). As a result of this coordination of effort there have been a number of events held in the past several years relating to manure management, and more broadly, environmental management of livestock operations.

- A composting workshop was held in conjunction with the Composting Council of Canada and the Saskatchewan Waste Reduction Council in Saskatoon in the fall of 1998. The objectives of the workshop were to: 1) provide the livestock producers with up-to-date expert information on composting as a treatment option for various types of livestock manures; and 2) provide a forum for discussion of composting as a manure management treatment option in Saskatchewan.
- The first Tri-Provincial (Manitoba, Saskatchewan, and Alberta) Manure Management Conference was held in the summer of 1999. The primary objective of the conference was to provide a forum for stakeholders to exchange information on sustainable manure management practices.
- A Water Quality and Manure Management Workshop was hosted in 1999 by Saskatchewan Agriculture and Food in conjunction with the Prairie Farm Rehabilitation Administration (PFRA). The objective of the workshop was to provide extension agrologists with information on water quality and manure management.
- In the summers of 2000 and 2001, Manure Management Field Tours were coordinated by Saskatchewan Agriculture and Food in cooperation with Prairie Agriculture Research Institute and the University of Saskatchewan. In 2000, a one-day field tour was organized and in 2001 four half-day field tours were hosted.
- In 2002, the second Tri-Provincial Manure Management Conference was held in Saskatoon. The objective of the conference was to promote manure management stewardship by providing principles, practices and planning tools for effective manure management for producers and agrologists.
- In February 2003, Saskatchewan Agriculture and Food cooperated with the Saskatchewan Watershed Authority on a one-day workshop for cattle producers dealing with water quality. Saskatchewan Agriculture and Food provided information on manure management at this forum.
- In the summer of 2003, a one-day Manure Management Tour was hosted by Saskatchewan Agriculture and Food.
- In 2004, a one-day Manure Management Workshop was held in Saskatoon to discuss manure storage, manure treatment, manure odour, and manure application and use. This workshop primarily focused on the current state of knowledge in the Saskatchewan research community and also provided some information on new technologies for manure treatment from Saskatchewan and Manitoba. In addition, the workshop was used to help identify and prioritize research gaps. The compiled information on research gaps was provided to provincial funding agencies.
- In the fall of 2004, Saskatchewan Agriculture and Food, Saskatchewan Environment, and Saskatchewan Waste Reduction Council, along with a number of provincial and federal agencies, hosted "Composting Matters!", a two-day conference on organics recycling and composting in Brandon, Manitoba.
- The third Tri-Provincial Manure Management Conference, entitled "Growing the Livestock Industry" and sponsored by Saskatchewan Agriculture and Food, was held in Saskatoon in 2005. The two-day conference included workshops, presentations and tours on manure management topics such as: the Kyoto Accord - what does it mean for the producer?; nutrient management; stewardship and water protection; and environmental management systems. The conference also included the option of a manure treatment technologies tour, a composting workshop or a manure management workshop highlighting the MARC (Manure Application Rate Calculator) software.

Table 34. Manure management workshops.

Year and event	Number of Participants
1998 - Composting Workshop	75
1999 - Tri-Provincial Manure Management Conference	305
2000 - Manure Management Field Tours	110
2001 - Manure Management Field Tours	10 – 30 /tour
2002 - Tri-Provincial Manure Management Conference	100
2003 – Water Quality Workshop	60
2003 – One-day Manure Management Tour	35
2004 – Composting Matters Conference in Brandon, MB	75
2004 – Composting Conference in Saskatoon	50
2005 – Tri-Provincial Manure Management Conference	200

Data Source: Locations of stewardship workshops delivered by the Saskatchewan Watershed Authority are from the Authority's Landowner Information Database. Information about the Environmental Farm Planning Workshops was provided by the Provincial Council of Agriculture Development and Diversification Boards (PCAB) and the Prairie Farm Rehabilitation Administration (PFRA). Saskatchewan Soil Conservation Association information was provided by Juanita Polegi (Pers. Comm.). Information about the manure management workshops was provided by Karen Bolton (Pers. Comm.)

Data Discussion: The intention of this indicator is to include and map all of the stewardship workshops by watershed. Through the cooperation and collaboration of various organizations, we are currently in the process of obtaining data on additional workshops to be included in this indicator.

Watershed Planning Indicator

What is this indicator, and why is it important?

This indicator assesses the measurable attributes of watershed and aquifer planning. Watershed and aquifer planning for source water protection is integral to successful watershed management.

The objective of the watershed planning process is the development of a plan that will take measures to improve water quality and work towards sustainable water quantity management. During the planning process, awareness of watershed issues is raised through the stakeholders (i.e. opinion leaders) involved with the process. In addition, awareness is raised through the local residents through public information meetings, workshops, field days, newsletters, and bringing these issues to the attention of the local media. A direct link is also made with the Watershed Education Indicator, as the watershed planning process will bring focus upon education programs for communities within the particular watershed. A product of watershed and aquifer planning is stewardship programs that are directed to rural or urban clients. Beneficial/Best Management Practices with partners will raise awareness of watershed management within the particular watershed.

Measure: Measurable attributes of watershed and aquifer planning include:

- Number of watershed or aquifer plans for the area covered by the State of the Watershed Reporting that have been completed within a ten-year time frame.
- Participation rates by the local stakeholders such as municipalities, First Nations, irrigation districts, watershed associations, conservation groups, and stewardship groups.
- Scope of recommendations and key actions that are developed during the planning process.

- Number of newsletters, workshops, watershed tours, and local media stories about the planning process.
- The completion of recommendations and key actions during the implementation phase of the process. This aspect will be measured at one year, three years, and five years after the completion of the plan.
- Percentage of key stewardship and water conservation actions that are implemented both during and after the process.
- Stakeholder acceptance and support for planning upon completion of the planning phase. Measurable through focus group surveys of the Watershed or Aquifer Advisory Committees.
- Public awareness of source water protection issues. Measured through telephone surveys before and after the watershed or aquifer planning process.

Data:
The data for this indicator is gathered during the planning process.

Sample watershed: The Upper Qu'Appelle River Watershed is a priority watershed in which the planning process has started.

- Number of watershed or aquifer plans for the area covered by the State of the Watershed Reporting that have been completed within a ten-year time frame: 0.
- Participation rates by the local stakeholders such as municipalities, First Nations, irrigation districts, watershed associations, conservation groups, and stewardship groups.
- Number of recommendations and key actions that are developed during the planning process.
- Number of newsletters, workshops, watershed tours, and local media stories about the planning process: 10.
- The completion of recommendations and key actions during the implementation phase of the process: N/A.
- Number of stewardship and water conservation actions that are implemented both during and after the process: N/A.
- Stakeholder acceptance and support for planning upon completion of the planning phase: N/A.
- Public awareness of source water protection issues. Measured through telephone surveys before and after the watershed or aquifer planning process.

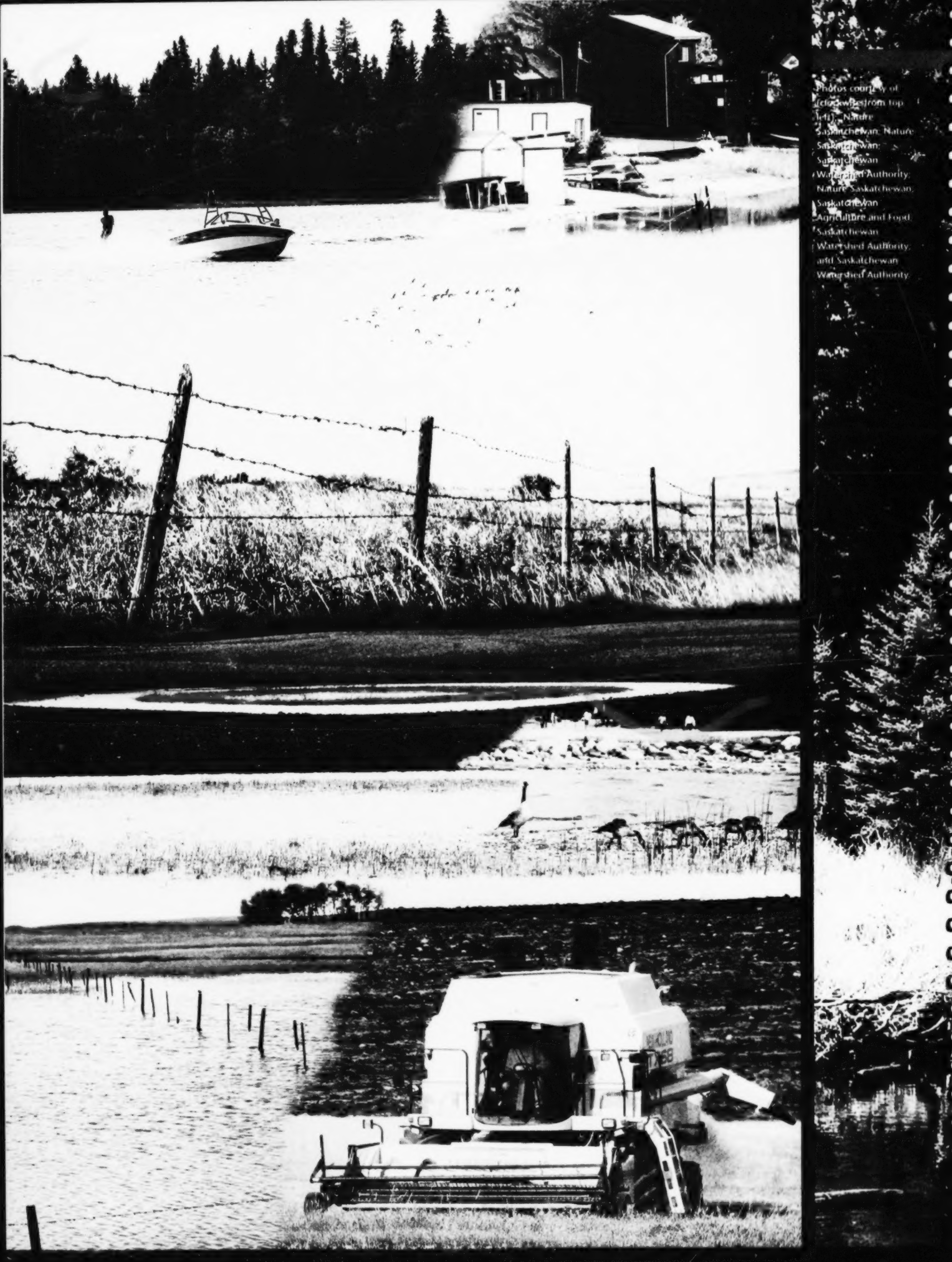
A follow-up survey will be conducted in the Upper Qu'Appelle to determine knowledge of water issues. The results from this survey will be compared with the attitudes measured in a pre-planning telephone survey (Metz 2004).

Table 35. Number of informative media releases designed to increase public awareness of the planning process in the Upper Qu'Appelle River Watershed.

Indicator	Number
Newsletters	1
Workshops	1
Watershed tours	3
Local newspaper stories	4
TV stories	1
Total number of media releases	10

Data Source: Information on the number of informative media releases used in the Upper Qu'Appelle River Watershed was obtained from the Saskatchewan Watershed Authority.

Response Indicators under construction include:
Municipal Wastewater Treatment Indicator;
Lake Stewardship Indicator;
Water Quality Monitoring Indicator;
Water Quantity Monitoring Indicator;
Conservation Easements Indicator;
Legislation and Bylaws to Protect Source Water Indicator; and
Land Use Planning Indicator.



Photos courtesy of (clockwise from top left): Nature Saskatchewan; Nature Saskatchewan; Saskatchewan Watershed Authority; Nature Saskatchewan; Saskatchewan Agriculture and Food; Saskatchewan Watershed Authority; and Saskatchewan Watershed Authority.

Photos courtesy of (clockwise from top left): Nature Saskatchewan, Nature Saskatchewan, Saskatchewan Watershed Authority, Nature Saskatchewan, Saskatchewan Agriculture and Food, Saskatchewan Watershed Authority and Saskatchewan Watershed Authority

8.0 Appendix

Appendix 1. Spatial Weighting

All the information in this document is presented by watershed. However, the source information is often tabulated by some other area unit [e.g. Consolidated Census Subdivision (CCS) for the Census of Agriculture data, as shown below in Figure 32a.] Converting information to the watershed level is accomplished by weighting the source information according to the area that the source area unit occupies of a given watershed. For example, to calculate the head of cattle per watershed, the head of cattle in each CCS is multiplied by the fractional area of the watershed(s) it occupies, as shown in Figure 32b.

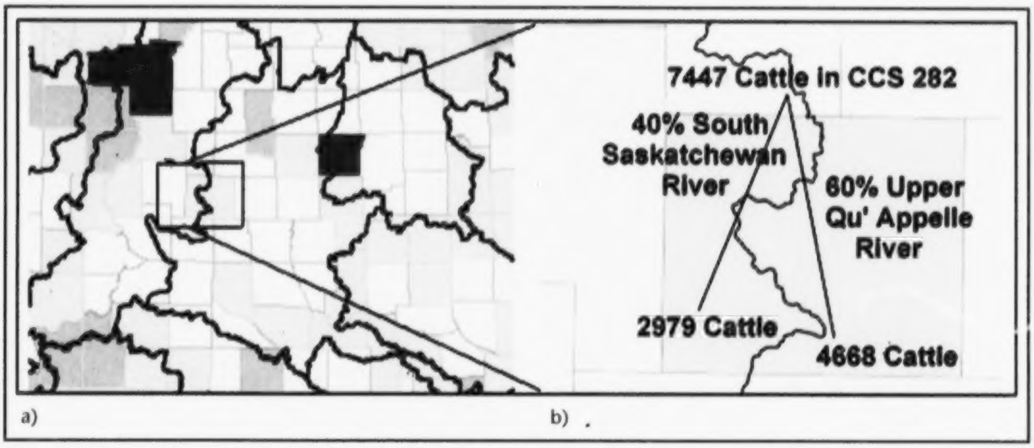


Figure 32. a) Watershed and CCS boundaries; b) Fractional area of CCS in watershed.

All Consolidated Census Subdivisions are then summed over each watershed to yield an estimate of the number of cattle per watershed, according to (9).

$$b_{xi}=\sum_{k=1} p_{xk} \times v_{ki} \quad (9)$$

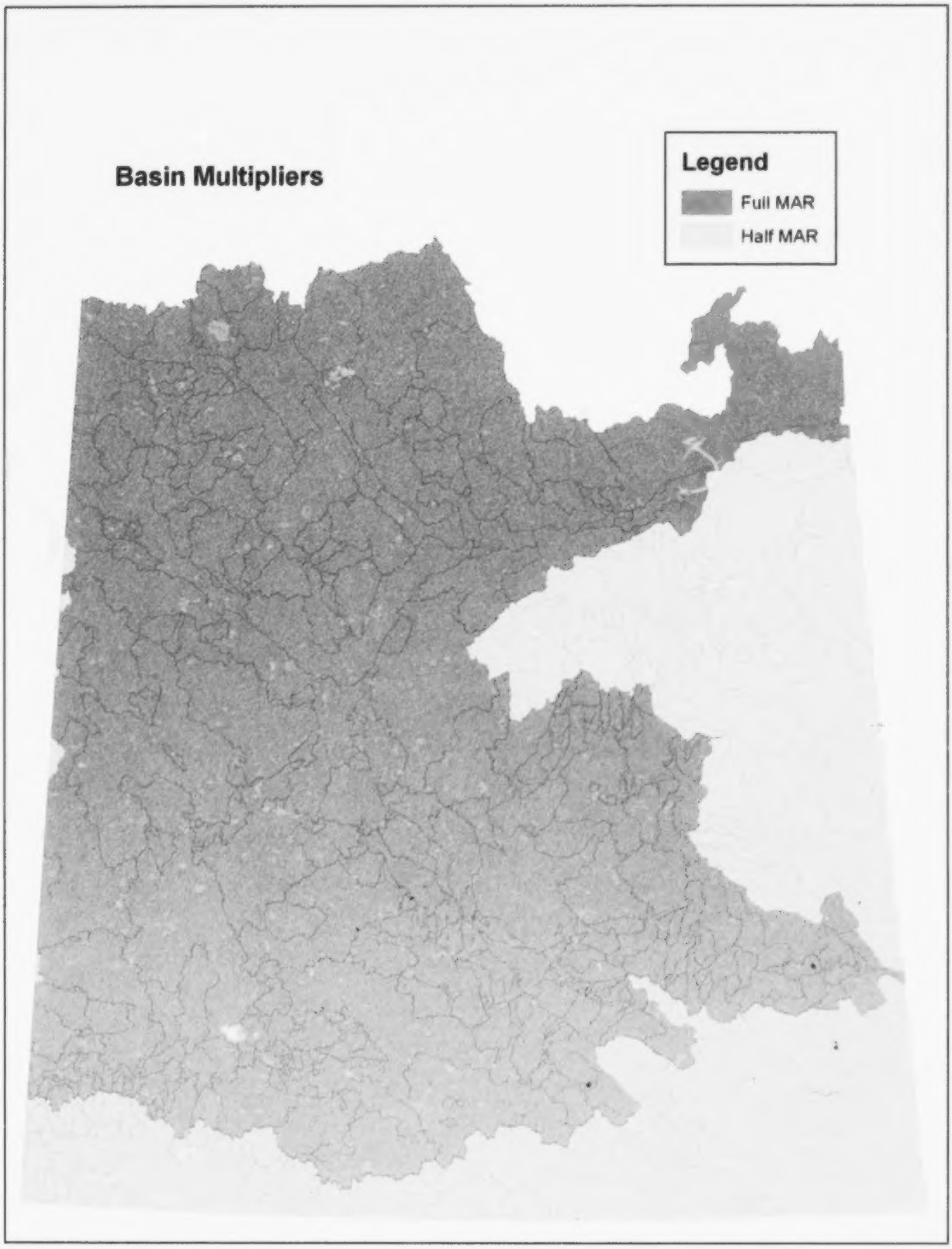
Where: b_{xi} is the score for watershed x on indicator i, e.g. head of cattle

p_{xk} is the proportion of source area unit k, e.g. CCS, in watershed x

v_{ki} is the value of indicator i in source area unit k

This method assumes that the source phenomenon is equally distributed across the watershed. This assumption is violated to varying degrees, but the method is certainly sound enough for the purposes of this exercise, which are coarse-level and intended only to intelligently maintain dispersion over a gradient.

Figure 33. Basin Multipliers.


Basin Multipliers
Legend
▨ Full MAR
☐ Half MAR

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11.0 Glossary of Terms

Animal Unit Equivalent: (AUE) is a live weight of 455 kilograms (1,000 lbs.) of livestock or any combination of livestock, poultry and farmed game that equals 455 kilograms. AUEs allow standardized waste and manure impact assessment across animal species. Stocking Rate and Carrying Capacity are expressed in Animal Unit Month (AUM), which is the amount of forage required by one Animal Unit in one month.

Aquatic Habitat Fragmentation: Breaks in continuous habitat, ecosystems or land-use types into smaller fragments. Fragmentations results from natural causes such as beaver dams, or manmade control structures.

Aquifer: A geologic formation which contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Biodiversity: The variety of plant and animal life in the world or in a particular habitat.

Cubic Decametre: 1 dam^3 = 1000 cubic metres (1000 m^3) = 1 million litres.

Ecosystem: The interaction of living organisms with each other and their environment as a single functioning unit.

Eutrophication: The nutrient enrichment of a waterbody, causing increased algal blooms and aquatic plant growth and, ultimately, a depletion of dissolved oxygen.

GIS (Geographical Information Systems): A computer system for capturing, storing, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Data might be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads).

Gross Watershed or Incremental Gross Drainage Area: Includes the effective and non-effective drainage area for a hydrometric gauging station.

Gross Water Availability: Is the total amount of water available for development along a stream or within a watershed without accounting for existing or proposed internal water allocations. It is multiplied by either one-half or the full annual unit runoff, depending on downstream allocations. The multiplier is one-half if the watershed is part of an international basin (e.g. Souris River) or interprovincial basin (e.g. Assiniboine River).

Groundwater: All subsurface water distinct from surface water, specifically within the saturated zone of a defined aquifer.

Hydrology: The study of the storage and movement of water on and below the earth's surface and within the atmosphere.

Intensive Livestock Operation: The confining of one animal unit to less than 370 square metres (or 4,000 square feet).

Instream Flow/ Environmental Flow: The amount of water flowing through a stream course that is needed to achieve environmental management objectives.

Land cover: Refers to habitat or vegetation class type (e.g. forest or grassland).

Land use: Refers to how humans use an area. Land cover and land use are related, but not equivalent, terms.

Net Water Availability: Is calculated as the gross water availability minus the surface water allocations. Typically expressed in cubic decametres.

Non-Effective Drainage Area or Areas of Non-Contributing Drainage: Non-contributing areas do not contribute to downstream accumulations of stream flow for a median (1:2) annual runoff.

Non-Point Source Pollution: Non-point source pollution comes from many diffuse sources. Transported with runoff, these pollutants are deposited into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include: excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas; petrochemicals from urban runoff and energy production; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; salt from irrigation practices and acid drainage from abandoned mines; and bacteria and nutrients from faulty septic systems.

Point Source Pollution: Pollution originating from a single location or source such as pulp effluent, wastewater effluent or an oil spill.

Response Indicators: Represent the management plans implemented to improve the state of the watershed. These are measured by how effective the plan was in improving the state of the watershed.

Riparian Areas: Transition zones between land and water environments. They are narrow strips of land along streams, lakes, potholes, springs, coulees, wooded draws, or anywhere water is plentiful. Riparian areas are defined by vegetation that is different than that upland while providing a unique role socially, economically and ecologically.

Range Site: Is "an area of rangeland which has the potential to produce and sustain distinctive kinds and amounts of vegetation to result in a characteristic plant community under its particular combination of environmental factors, particularly climate, soils, and associated native biota" (Jacoby 1989).

Stewardship: Caring for land and associated resources and maintaining healthy ecosystems for future generations.

Unit Net Water Availability: Is the net water availability divided by the basin area. Typically expressed in millimetres of unit runoff, which is equivalent to dam^3/km^2.

$$\text{Unit Runoff} = \frac{\text{Annual volume } (dam^3)}{\text{Effective drainage area } (km^2)}$$

Upland: An area of land that lies above the floodplain. It is characterized by vegetation that relies on precipitation for its water source.

Watershed: A geographic area defined by topographic divides that has a common outlet for its surface runoff.

Watershed Health: A healthy watershed can provide natural maintenance, integrity and ecological processes.

12.0 Contributors

Contributors include representatives from the Saskatchewan Watershed Authority (SWA), Saskatchewan Highways (SH), Saskatchewan Environment (SE), Saskatchewan Agriculture and Food (SAF), Ducks Unlimited Canada (DUC), Saskatchewan Industry and Resources (SIR), Prairie Conservation Action Plan (PCAP), Partners FOR the Saskatchewan River Basin (PFSRB), Saskatchewan Soil Conservation Association (SSCA), and Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB).

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